Cadent
Your Gas Network

Appendix 09.06

London Medium Pressure

RIIO-2 Spend: XXXX

Investment Decision Pack Overview – London Medium Pressure

This Major Project Engineering Justification Framework outlines the scope, costs and benefits for our proposals. We have prepared this document and a Cost Benefit Analysis (CBA) for this project.

Overview

Throughout RIIO-1 we have been working towards replacing strategic ring mains in our London network. These Victorian assets are aging, are at the end of their serviceable life, and are failing. Moving forward into RIIO-2, we need to continue to replace metallic mains to reduce risk and increase resilience of our central London network.

Failure of assets along the route of the London Medium Pressure (LMP) project can be particularly challenging as they are of very large diameter which makes repair on failure extremely disruptive. The assets are on arterial routes through the capital, passing major landmarks such as the Houses of Parliament, Trafalgar Square (as well as many others) so failure and subsequent repair which can lead to sever disruption to traffic, tourism and commerce. Past asset failures have led to the evacuation of thousands of people in the properties neighbouring assets as the buildings are in very close proximity to high population buildings, this includes nationally important buildings with priceless artefacts and works of art.

Of the 26km that are in-scope of the LMP project 6.1km (24%) are already above the safety thresholds we are proposing for RIIO-2. If we were not proposing the LMP project as an integrated scheme, then the renewal of these assets would have been identified in our core mains renewal programme.

Replacing these assets is challenging – the existing pipes are in areas that are very difficult to access, or which pose significant engineering challenges (many near major structures, in subways, or in locations controlled by other stakeholders), the degree of third-party interfaces means longer design and construction timescales, and there is a need to ensure security of supply in the Medium Pressure (MP) network while the works are ongoing. We have taken lessons from RIIO-1 and our ongoing engagement with local authorities, stakeholders and customers to set out a programme that will allow us to reduce risk, increase resilience and manage disruption to the communities we serve. For these reasons, we are proposing a longer delivery window for the remainder of the LMP project, completing in 2031 rather than 2029 which was the original RIIO-1 plan.

The original RIIO-1 feasibility study for the project remains valid. As such we are not proposing to re-open the preferred option, or overall strategy for the project. We have however updated the CBA for the LMP to demonstrate the value that the overall scheme will deliver, using the latest cost and benefit estimates. This shows that the overall scheme is cost beneficial (with an NPV of *XXXX*).

There is one section of the LMP where there are two fundamentally different route and solution options to be considered (Monck St to Farringdon St, and Monck St to New Bridge St) which both follow the routes of existing pipes and hence are both consistent with the original strategy. We undertook a comparison of engineering benefits and risks for these two routes and concluded that the Monck St to Farringdon St is the most viable scheme, with the most manageable range of risks, which also maximises network resilience.

We are therefore proposing to continue to deliver the LMP project over RIIO-2 and RIIO-3. Overall, this will involve the renewal of 26km of existing assets and the laying of 1km of new assets to complete the project. For RIIO-2 we are requesting 50% of the remaining investment required - *XXXX* to address 13km of asset.

Summary of preferred option	£
RIIO-2 Expenditure	Redacted due to commercial sensitivity
Project NPV (RIIO-2 and 3)	

Material changes since October: As signalled in our October submission we have now completed more detailed costing work where we have identified the key mains laying activities for each activity for each specific section of the project. Where possible, this has been undertaken following a site survey, however some projects have only been possible using the drawings. We have also updated our CBA approach so that the make-up of buildings and population densities around specific schemes can be identified more clearly.

Table of Contents

1. Table of Contents 2
2. Summary Table 6
3. Project Status and Request Summary 7
4. Problem Statement 9
4.1. Related Projects 11
4.2. Project Boundaries 11
5. Project Definition 12
5.1. Supply and Demand Scenario Discussion and Selection 12
5.2. Project Scope Summary 12
6. Options Considered 14
Background and introduction 14
6.1 Baseline option: Reactively repair pipework upon failure. 16
6.2 Option 1: Proactive programme of work to upgrade and replace identified assets 16
6.3. Option Cost Estimate Details 19
6.4. Options Summary 21
7. Business Case Outline and Discussion 22
7.1. Key Business Case Drivers Description 22
7.2. Supply and Demand Scenario Sensitivities 22
7.3. Business Case Summary 23
8. Preferred Option Scope and Project Plan 25
8.1. Preferred Option for this Request 25
8.2. Project Spend Profile 25
8.3. Efficient Cost 26
8.4. Project Plan 26
8.5. Key Business Risks and Opportunities 27
8.6. Outputs Included in RIIO-1 Plans 28
9.0 Regulatory Treatment 29
Appendix 1. Location Map 30
Appendix 2. Solution Options 31
Section 1. Belgrave Square to Monck Street 32
Section 2: Salmon Lane to Commercial Road 34
Section 3: Commercial Road to Farringdon Street 36
Section 4: Commercial Street to Plough Yard 39
Section 5: Farringdon Street to Plough Yard 40

Section 6/7/9: Bow Common Lane to East India Dock Road, Commercial Road and Goswell Road 42
Section 8: Bromley by Bow to Bow Common Holder 47
Section 10 & 11: Route from Monck Street to Farringdon Road or New Bridge Street..... 49
Section 12: Farringdon Street..... 55
Appendix 3. Key challenges: LMP overall Scheme 57
Appendix 4. Example of Recent Mains Failure in London – Consequence of Failure 59
Appendix 5. CBA Basis of calculation..... 60
Appendix 6. Customer Engagmenet..... 66

2. Summary Table

Name of Project	London Medium Pressure		
Scheme Reference	Cadent Line Reference 003		
Primary Investment Driver	Asset Health and Resilience		
Project Initiation Year	2013		
Project Close Out Year	2031		
Total Installed cost estimate (£)	Redacted due to commercial sensitivity		
Cost Estimate accuracy (%)			
Project Spend to date (£)			
Current Project Stage Gate	Delivery phase 1 and feasibility study and planning phase 2		
Reporting Table Ref	North London. Repex 4.03 Tier 3 and.3.06 Other Capex		
Outputs included in RIIO-1 Business Plan	The first phase of the LMP was included in RIIO-1. The elements proposed relate to the second phase.		
Spend apportionment	**RIIO-1**	**RIIO-2**	**RIIO-3**

Table 1: Summary Table for London Medium Pressure Project

3. Project Status and Request Summary

In 2012 the Health and Safety Executive completed a 10 Year Review of their enforcement policy for the replacement of iron gas mains[1]. This review looked at the effectiveness of the programme and considered how the Iron Main Replacement Programme (IMRP) should evolve 10 years in. The key change that resulted from this was the adoption of the Three Tier Approach that came into effect at the start of RIIO-1. The impact this had on our investment plans was significant for our large diameter mains (greater than 18"). The framework moved from a position of mandated replacement of all mains by 2032 to any mains larger than 18" being replaced on a cost benefit basis with networks operating a maintenance regime (effectively the gas emergency service) for these assets. This significantly reduced workload and interrupted strategic plans for replacement of these assets over the course of the programme. Whilst the enforcement policy changed, their remained an absolute duty of network companies to comply with the requirements of the pipeline safety regulation (PSR), 1996.

In response to this we looked at the risk on our large diameter network in respects of safety and security of supply across our networks. The outcome of this work led us to propose the London Medium Pressure (LMP) replacement programme in RIIO-1. The programme, as we set out in RIIO-1, focused on the highest risk strategic ring mains in our central London network with the aim of creating a combined MP/IP network that would both reduce risk and increase resilience. No other area of our networks was identified as having the same complexity of issues, and as such no similar schemes were proposed for other areas of the country, this remains the case.

In scoping this programme in RIIO-1 we brought forward and refined our long-term plans to focus on the highest priority mains (previously we had been systematically replacing the MP network working from the outside into the centre of London). We proposed circa 98km of work in RIIO-1 to start this project which we had planned to complete over 16 years (at that point 2 eight-year price control periods). This was supported by a scheme by scheme design and cost benefit analysis (CBA) that factored on the risk faced in our London network with its high density of multi occupancy buildings, population density and buildings of national importance. Within the timeframes we worked to in RIIO-1 we did not have enough time to fully engage with local authorities, TFL and other stakeholders on the exact form of the programme. We agreed with Ofgem 69km programme as part of the final determinations.

Moving into delivery for RIIO-1 as we completed detailed designs, planning and the initial engagement with stakeholders it became clear that we would need to reconsider our plans. This was primarily driven by difficulties in gaining access to our assets and to ensure that we managed the programme in a way that minimised disruption for the communities we were working in. Because of this we reworked our programme and targeted a revised total delivery length of 48km for the programme. This would result in an under delivery against our RIIO-1 length, although we would still meet our risk removed targets and our overall primary outputs. We proactively engaged with Ofgem on this issue and as a result returned the difference *XXXX* in 18/19 prices) in the allowance between final plan allowance and the final scope of the RIIO-1 works in the RIIO-1 period.

This Major Project Engineering Justification builds on the work we have completed in RIIO-1 setting out our proposals for completion of the LMP scheme over a revised timeframe. We have taken lessons from RIIO-1 and our now ongoing engagement with local authorities, stakeholders and customers to set out a programme that will allow us to reduce risk, increase resilience and manage disruption to the communities we serve. We have used our learning from RIIO-1 to develop reasonable timescales for delivery of the remaining remediation over RIIO-2 & 3. As the design and construction of the first phase of this project has progressed in RIIO-1, we have revised our assumptions on complexity and construction risks associated with this project, we have factored this into the approach we are taking for RIIO-2 and beyond.

There are a number of risks associated with this ambitious project, the most material are set out below:

[1] http://www.hse.gov.uk/gas/supply/mainsreplacement/10-year-review.htm

- The existing pipes are in areas that are very difficult to access, many near major structures; they are in service subways or locations controlled by other stakeholders.
- The location of these assets poses significant engineering challenges, requiring complex optioneering and stakeholder engagement to finalise.
- There is a significant volume of third-party interfaces with numerous stakeholders, leading to greater design and construction timescales.
- There is a need to ensure security of supply within our London medium-pressure network while the works are ongoing.

For these reasons, we have proposed a slightly longer delivery window for the remainder of the LMP project, completing in 2031 rather than 2029, which was the original RIIO-1 plan. This is a lower-risk delivery plan to enable greater control throughout RIIO-2 and 3.

The funding required for RIIO-2 and 3 will be sufficient to complete the outline and detailed design and to fully construct and commission the following scope of work:

- The abandonment of 26km of existing asset
- The construction of 13.7km of new asset (through insertion of the old assets or open cut)
- Replacement of 13 governors

4. Problem Statement

Within the scope of the RIIO-2 and 3 phases of the LMP project, there are 26km of aged Victorian metallic medium-pressure gas pipelines up to a diameter of 48". These are large diameter pipes that run near buildings of national importance such as Buckingham Palace, the Houses of Parliament and Charing Cross Station. This is a unique urban geography with a tight juxtaposition of asset providing vital services with the critical buildings that they serve.

These assets are at the end of their serviceable lives and are failing. We have an absolute legal and moral duty to maintain assets in efficient working order. If we do not invest to replace these assets, failure will put a significant number of people at risk from any resulting gas-escape, as well as impacting on vital national services.

Investment in these assets has a resilience benefit as it will allow the assets to operate at higher pressures, reducing the risk of interruption in case of failures elsewhere on the network.

Investment drivers

The drivers of investment for the LMP project include safety, security of supply (resilience) and efficient network operation. All these drivers provide benefit to customers and are discussed below.

Safety: Safety is consistently highlighted as the most important, or joint most important investment driver during customer research. Ninety four percent of respondents to our domestic survey said that safety of the network was very or quite important to them.

We also have an absolute duty to operate safely with obligations under the Pipeline Safety Regulations (1996): "The operator shall ensure that a pipeline is maintained in an efficient state, in efficient working order and in good repair" (Regulation 13).

The LMP assets are up to 120 years old; and show clear signs of deterioration (ageing). Over the course of RIIO-1, there have been 47 mains failures on the assets within the proposed scope of works. Although we have been able to manage these failures to prevent explosion, they have been very disruptive to smooth running of the city. We have included a specific example of a recent failure at Horseferry Road, showing the risks these iron mains pose, in Appendix 4.

Compared to low-pressure mains, medium-pressure mains present a greater risk of incident because gas escapes at a much greater rate through a defect or fracture. A high gas-escape rate is more likely to result in a flammable volume of gas arising in buildings.

Many medium-pressure mains in the centre of London are in very close proximity to buildings, some of which are very significant landmarks, with no open ground between the main and the property. The lack of open ground between the pipe and the property increases the likelihood that it will enter the building increasing the risk of explosion. Central London also has a large number of cellars which also increase the safety risk, as the underground void is an easy place for gas to migrate to. In addition, cellars are often unoccupied; therefore, the escaping gas can accumulate and reach an explosive mixture undetected.

As detailed 'Appendix 09.02 Distribution Mains and Associated services (Iron, PE, Steel & Other)' we are introducing a safety threshold for all pipes that have an MRPS (Mains Replacement Prioritisation System) risk score. Of the 26km that are in-scope of the LMP project 6.1km (24%) are already above the proposed safety thresholds. That is to say, applying the HSEs assessment of acceptable risk to these pipelines would results in them being flagged for replacement. If we were not proposing the LMP project as an integrated scheme, then the renewal of these assets would have been identified in our core mains renewal programme.

There are many nationally important buildings situated within close proximity of the remaining 'in-scope' medium-pressure mains in London. If there were an incident on these mains, there would be significant consequences due to the nearby buildings having hundreds or even thousands of occupants.

Resilience: Central London is critical to the UK and a large gas supply failure preventing customers from accessing energy is not an option. The LMP project allows pressure elevation in the centre of the city to 2 bar, this improves network resilience reducing the likelihood of interruptions to supply on both the medium and low-pressure network. With the addition of governors, feeding into the network at strategic locations, further resilience can be provided to customers in the event of an asset failure.

Energy consumption in London is predicted to increase, and the gas network will continue to play a vital role with power generation sites and the 'greenification' of the energy mix, with renewable energy (bio-gas) connections. At present, there are eight new PowerGen connections currently accepted on the London Network. These connections will create a greater gas-demand and we need to a pipework that can operate with these demands.

Operability: Ensuring the completion of the Belgrave Square to Monck Street scheme will allow the pressure elevation of the west side of London to be completed to 2bar. This improves network resilience significantly by eradicating the current one-way fed main, which would be left to the Hyde Park site at the end of the RIIO-1 works. This also extends the allowable operating windows on the network and means that (planned or reactive) work can be carried out in at least two locations at one time without interrupting supplies.

The completion of the entire scheme simplifies the operability of the MP network (reducing the number of changes to network configuration such as pressure settings), especially as the number of sites that are required to cycle in pressure, to a maximum of 0.55bar, in line with seasonal demands will be reduced and will instead be feeding in at a constant pressure of 2bar. This was historically managed to reduce leakage on the system and, with the replacement of the mains within the scope of RIIO-2, will no longer be required within this newly created system.

In addition to the three areas set out above there are important economic and societal risks associated with failure of these assets:

- Financial losses from damage to high value building and their contents
- The potential for significant national outcry and societal effects associated with damage to internationally known landmarks
- Disruption to the smooth running of the city – cutting transport links (major roads, tube lines, railway stations), stopping work in large institutions with thousands of occupants being evacuated, failure to supply the energy needed to keep by the city.

Project challenges and complexities

Working in the heart of London on a large engineering project has unique challenges associated with it. Key risks are listed in Section 3. In summary, these Victorian pipes are in heavily congested inner London streets, with many complex interfaces with other structures and services to manage. Any construction activities in these areas require extensive and time consuming third-party consultations.

A detailed summary of some of the most significant project challenges have been included in an appendix, but in summary these are comprised of:

- **Subways:** The only safe engineering solution for laying new pipes in subways is to install new steel mains. To install new mains in subways requires significant works to get access to lay the pipe.
- **Road Space:** Road space in London is at a premium. Where we are required to open cut sections of pipe finding a route is challenging.
- **Assets in and around Rotherhithe Tunnel:** Transport for London (TFL) have said that they will not allow closure of the tunnel until there are planned works there to repair the tunnel (there are 30-40 thousand vehicle movements through the tunnel each day). We cannot renew this section until TFL allow us to, this could add delay to the completion of the project.[2]

[2] It should be noted that a mains failure at the Tunnel or Liverpool Street station would create unplanned disruption which would have a larger impact that a managed programme of work.

- **Liverpool Street Station:** Our pipelines go under the station in a utility subway. This present unique challenges in working at this location as significant disruption would need to be mitigated at one of London's major transportation hubs.
- **Stakeholder and Customer Impact:** The preferred route of the LMP project goes past very sensitive locations; careful stakeholder and customer management will be required to minimise impact.

Key milestone dates

Our high-level programme is set out below:

- **RIIO-1 –** delivery of the remainder of the planned RIIO-1 works
- **Autumn/Winter 2019 –** continuation of stakeholder engagement on the RIIO-2 scope of works
- **October 2019 –** detail costing exercise carried out in preparation for the final plan - COMPLETE
- **Remainder RIIO-1 –** design, planning and engagement for start of RIIO-2 delivery

A more detailed plan for RIIO-2 is not possible until further stakeholder consultation and greater levels of design are complete.

Understanding project success

A safe and reliable network which meets the needs of London in the 21st century. Success of the LMP project will include:

- The delivery of the scheme on time to cost.
- Success in how we work with customers and stakeholders in minimising disruption.
- Innovating to deliver the complex engineering required to complete this project.

This challenging project, when complete, is designed to remove the process safety risk posed by some of our Victorian metallic pipelines assets which operate at elevated pressures in the centre of London and which are near to nationally important buildings.

By the end of the project, 51km of aged Victorian metallic pipework (length slightly longer than the original 48km due to finalised scope) will be renewed with modern materials, allowing the centre of London to be served with a resilient medium-pressure network, protecting customers for generations to come. The project will reduce the likelihood of failure on the network, reducing customer disruption and decreasing the safety risk posed by these assets.

4.1. Related Projects

There are no directly related project linked with the LMP schemes.

4.2. Project Boundaries

The project is limited to the abandonment and replacement of mains (set out in 5.2) and any associated investment to install or resize pressure reduction governors. As such it contains elements of both capex and repex activity.

5. Project Definition

5.1. Supply and Demand Scenario Discussion and Selection

The LMP project is not supply dependent, the project focusses on removing the risk posed by ageing pipelines. Successful replacement of the pipes in scope allows for pressure to be elevated up to 2bar resulting in improved network resilience i.e. the network will be able to respond to a wider range of demand scenarios.

The network also has greater operability allowing for any future Power Generation, biogas or CNG fuelling sites to connect.

5.2. Project Scope Summary

The assets in scope of the remainder of the LMP project.

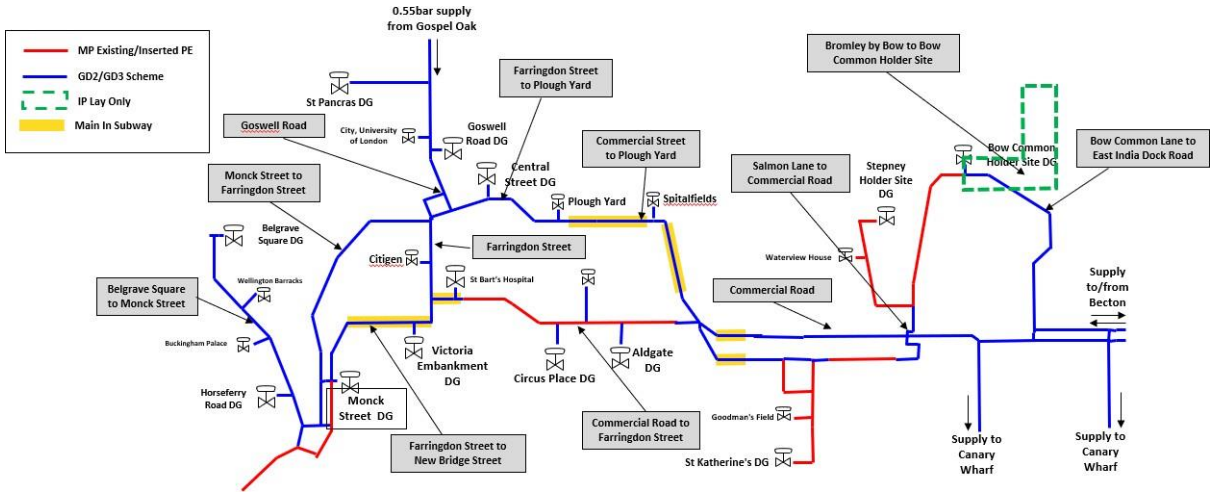


Figure 1: Remaining Assets in Scope of the LMP Project

At the end of the RIIO-1 period, there will be 26km of assets in the LMP programme that will need either abandonment or replacement in RIIO-2 and beyond. This project is made up of several defined sections that are defined in the table below.

From the sections identified there is uncertainty in the order in which they can be delivered as working in the heart of London requires significant stakeholder coordination. Because of this we are proposing an PCD to allow phasing flexibility in the delivery of the scheme in RIIO-2. See Section 9 for details on our proposal for LMP regulatory treatment.

Section	Assets within scope of RIIO-2 scheme	Mains Length (km)
1	Belgrave Square to Monck Street	2.8
2	Salmon Lane Bridge to Commercial Road	0.6
3	Commercial Road to Farringdon Street	1.0
4	Commercial Street to Plough Yard	1.1
5	Farringdon Street to Plough Yard	2.3
6	Goswell Road Abandonment	1.1
7	Commercial Road Abandonment	5.8
8	Bromley by Bow to Bow Common	1.4
9	Bow Common to East India Dock Road	0.7
10	Monck Street to Farringdon Road	4.6
11	Monck Street to New Bridge Street	3.7
12	Farringdon Street	1.0
	Total	**25.9**

Table 2: Discrete projects and scope remaining to complete the LMP project (note rounding accounts for the difference between scheme lengths and total)

In addition to the mains renewal there are 13 governors which will need investment which are in scope of the project.

6. Options Considered

Background and introduction

As discussed in Section 3, in preparation for RIIO-1 the medium pressure network in London was identified as needing investment due to increasing number of failures and safety risk posed by the assets as well as the requirement to increased resilience. Prior to RIIO-1, when the LMP scheme was first proposed to Ofgem, a detailed feasibility study and options analysis was completed, reviewing a wide variety of options.

Ultimately, **the preferred programme-option was to proactively renew mains in the centre of London (as detailed below),** as this programme contributed most towards the primary driver of decommissioning the highest-risk mains. An additional benefit of this option was that it mainly used insertion techniques to replace the mains which minimised disruption to customers and provided delivery at a cheaper cost.

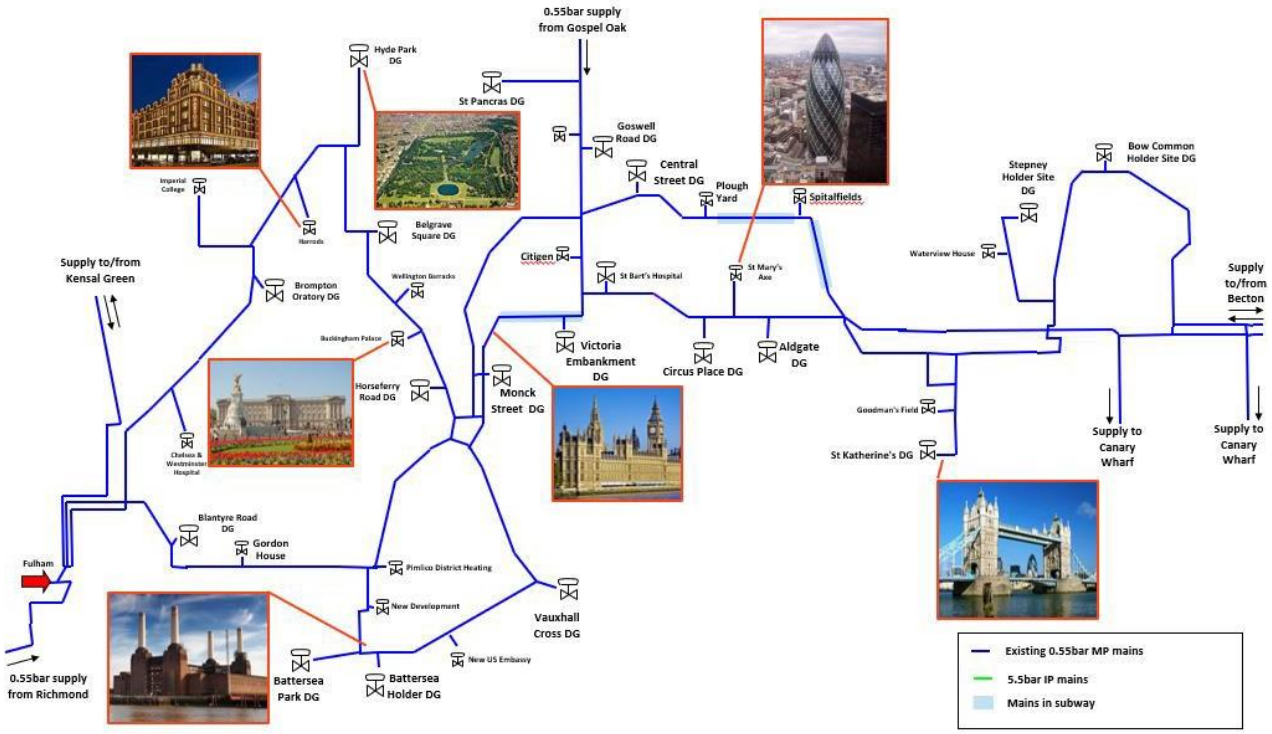


Figure 2: LMP Scheme as Proposed in RIIO-1

The strategy requires the construction of intermediate-pressure (2-7 bar) reinforcement main from East to West through the centre of London, the installation of new pressure reduction stations and the replacement of existing medium pressure iron pipes by mains insertion techniques. The route of this work followed existing assets where possible (to reduce costs) therefore the phasing of renewal needs to be considered so that the works can take place with minimal disruption to customers. The end state of the project agreed in RIIO-1 detailed in the map below.

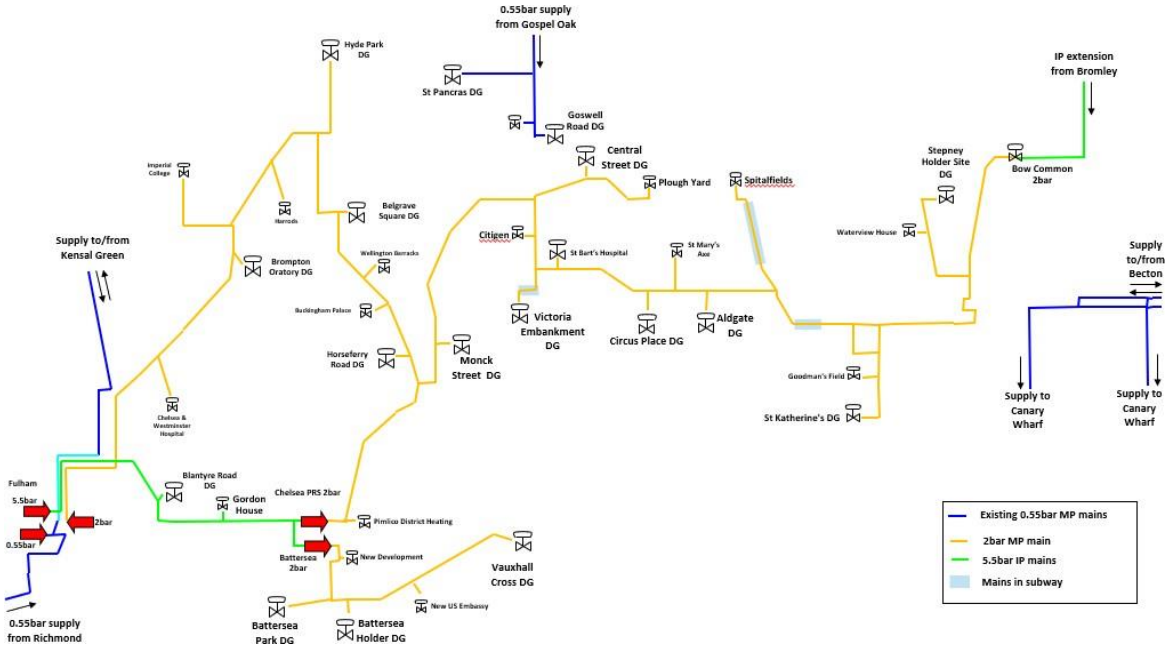


Figure 3: End State of Preferred Option for LMP

By the end of RIIO-1 we will have carried out a significant amount of work on the Western section of the project, replacing mains and increasing pressure from 0.55bar assets to 2bar or 5.5bar. We will have also replaced several other sections along the remainder of the scheme, however these cannot have their pressure increased until further renewal is carried out on their neighbouring sections, which cannot currently withstand the pressure increase.

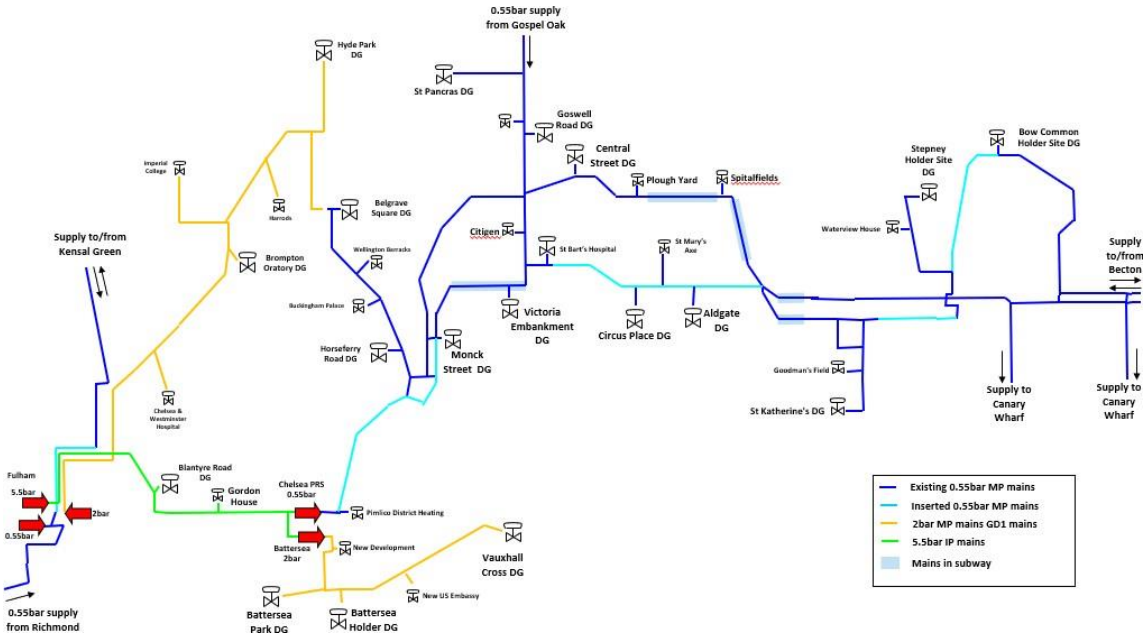


Figure 4: LMP Scheme at the End of RIIO-1

As part of our RIIO-1 plan, we demonstrated that our proposed LMP scheme was the optimum approach to managing the risk for our deteriorating iron mains within London, eight years on, we are confident that this choice is still optimum.

Within this paper we have therefore considered two programme options:

- **Baseline**: Reactively repair following failure (Once the RIIO-1 investment is complete)
- **Option 1**: Proactive renew prior to failure (RIIO-2 & 3 investment)

In section 7.3 a third option is identified, however this is the RIIO-2 investment detailed in Option 1 broken out for RIIO-2 investment analysis only.

6.1 Baseline option: Reactively repair pipework upon failure.

This option was reviewed in detail as part of our RIIO-1 submission and discounted. We have however included this option in our RIIO-2 submission for completeness, to demonstrate that the remaining investment in RIIO-2 is still warranted.

This option will have significant impact on our security of gas-supply to London and will also lead to significant disruption to very busy London roads, when we carry out the required repairs.

Any pipeline failures will also bring with it, a high risk of fire and explosion to the general public and could put nationally important buildings at risk.

We have used a cost benefit analysis of the programme to ensure overall value for money. Our approach is compliant with HM Treasury's Green Book and Ofgem's CBA guidance. Consistent with our approach for RIIO-1 and accepted by Ofgem we have reviewed the impacts when assets fail given the nature of the area affected, we have adjusted the property values and population of the properties reflect the area in question rather than the North London region in general.

For LMP the forecast failure rate and leakage were taken from analysis of current asset performance and deterioration based on statistical analysis. The cost to repair came from corporate data and the safety consequences were calculated for each section of the project.

Overall the benefits calculated for the CBA were:

- Cost to repair the pipe after a failure
- Leakage of gas from the pipelines and joints
- Property damage resulting from gas seepage into basements causing an explosion in a nearby building
- Fatalities within and outside of a building with the explosion
- Non-fatal injuries within and outside of a building with the explosion
- Traffic disruption due to repair activities

The probability of an explosion is calculated using the industry MRPS risk score (using the latest indicative MRPS results) for each section of pipe, which represents the expected average number of explosions each year. This probability is then increased through time at the same rate as the number of failures.

We then multiplied this probability of failure by the consequence in terms of property damage, fatalities, and non-fatal injuries to get the overall risk.

The potential consequences of failure considered for the LMP project have been expressed as monetary values as per the agreed NARMs industry methodology. A more detailed discussion of the risks this baseline option poses is included in Appendix 5.

6.2 Option 1: Proactive programme of work to upgrade and replace identified assets

The LMP project requires a further 12 sections to be completed in RIIO-2 and 3 (see Section 5).

We have carried out further study and design on these 12 sections of the scheme. The options investigated for each section is discussed in Appendix 2.

For all sections the least cost pipe-insertion method is the preferred option as it is considerably cheaper and less disruptive than any other pipe renewal method. CISBOT is not a suitable technique for the LMP project as it would not allow the increase in pressures required.

The preferred solution-options & scope of work for each section of the scheme is summarised below.

			Outline scope of work				
Section	Description	Preferred solution-option	Pipe insertion length (m)	Pipe open cut length (m)	Abandoned length (m)	AGI (governor) upgrades (nr)	Other scope
1	Belgrave Square to Monck Street	Pipe insertion along existing pipeline route	2.15	0.10	2.76	3	
2	Salmon Lane Bridge to Commercial Road		0.43	0.03	0.64	1	Shaft required to get under Commercial Road and Rotherhithe Tunnel approach
3	Commercial Road to Farringdon Street		0.13	0.78	1.00	3	Subway works
4	Commercial Street to Plough Yard		0.45	0.57	1.10	0	Subway works
5	Farringdon Street to Plough Yard		2.20	0.00	2.29	1	
6	Goswell Road	Abandonment	0.00	0.00	1.09	0	
7	Commercial Road	Abandonment	0.00	0.03	5.76	1	Subway abandonment complexities
8	Bromley by Bow to Bow Common	Pipe insertion along existing pipeline route	0.12	1.16	1.36	1	Tunnel under Blackwall Tunnel approach
9	Bow Common to East India Dock Road	Abandonment	0.00	0.02	0.67	0	Small length of open cut required
10	Monck Street to Farringdon Street	Pipe insertion along existing pipeline route	3.83	0.28	4.57	2	Assets encased in London Underground (tube) assets
11	Monck Street to New Bridge Street	Abandonment	0.52	0.02	3.70	1	
12	Farringdon Street	Pipe insertion along existing pipeline route	0.89	0.03	0.99	0	
		Total	**10.7**	**3.0**	**25.9**	**13**	

Table 3: preferred solution-options & scope of work for each section

6.3. Option Cost Estimate Details

This section focusses on explaining the **costs for the preferred programme option of proactively upgrading all 12 sections of the proposed scheme,** based on the preferred solution-options for each section (discussed in detail in Appendix 2).

For each section of the scheme, the scope of work has been estimated following either a detailed site survey or via a desk-top study reviewing all available drawings. A design and construction cost estimate (total installed cost) has then been developed for each section, based on the preferred solution-option.

Where possible we have used actual costs incurred in RIIO-1 to generate either a cost per metre or frequency of activity (i.e. Ground Penetrating Radar surveys every 1,000m on average). As an example, traffic management costs incurred to date have equated *XXXX* per metre on Fulham MP Project and have been used pro rata for each of the future works. This has been used as they are the most recent cost information available.

A summary of the major activities for each section of the project are detailed below.

Section	Valve Bagstops Stopples	Insertion & Reception Pits	Insertion (m)	Opencut (m)
1. Belgrave Square to Monck Street	13	23	2,150	100
2. Salmon Lane Bridge to Commercial Road	4	8	430	30
3. Commercial Road to Farringdon Street	9	6	125	778
4. Commercial Street to Plough Yard	2	5	450	565
5. Farringdon Street to Plough Yard	7	17	2,200	0
6. Goswell Road (Abandonment)	3	1	0	0
7. Commercial Road (Abandonment)	5	N/A	0	30
8. Bromley by Bow to Bow Common HS	5	2	120	1,162
9. Bow Common to East India Dock Road	4	N/A	0	20
10. Monck Street to Farringdon Road (Via Trafalgar Squ)	16	35	3,827	280
11. Monck Street to New Bridge Street (Abandonment)	4	7	520	22
12. Farringdon Street	6	7	892	30

Table 4: Summary of scope of work for LMP programme

The results of each of the elements of spend are then totalled to give a forecast spend to complete the LMP project. A summary of the section by section cost is detailed in the table below. Further detail on the specific schemes is included in Appendix 2.

Section	Length (m)	Majority Main Size	Total Cost (£m)	Total Unit Cost (£/m)
1. Belgrave Square to Monck Street	2,756	36"	Redacted due to commercial sensitivity	
2. Salmon Lane Bridge to Commercial Road	638	48"		
3. Commercial Road to Farringdon Street	999	48"		
4. Commercial Street to Plough Yard	1,096	48"		
5. Farringdon Street to Plough Yard	2,290	48"		
6. Goswell Road Abandonment	1,090	36"		
7. Commercial Road Abandonment	5,761	48"		
8. Bromley by Bow to Bow Common HS	1,359	48"		
9. Bow Common to East India Dock Road	668	48"		
10. Monck Street to Farringdon Road (Via Trafalgar Squ)	4,567	48"		
11. Monck Street to New Bridge Street (Abandonment)	3,701	36"		
12. Farringdon Street	994	36"		

Table 5: LMP Scheme Cost Estimates (Direct Costs Only)

The costs listed above are without Cadent overheads, an overhead of 13% has been applied to the direct costs to generate the final costs for the LMP project.

The following table presents the total installed cost for the entire LMP programme of work due for design and construction in RIIO-2 & RIIO-3.

Item	Capex Cost £	% of Total Installed Cost
Pipework renewals / abandonment		
Engineering Design		
Project Management		
Materials		
Main Works Contractor		
Specialist Services	Redacted due to commercial sensitivity	
Vendor Package Costs		
Direct Company Costs		
Indirect Company Costs		
Contingency		
Sub-Total installed costs: Repex		
Cost estimate accuracy		-
AGI Upgrades		
Sub-total: Capex[3]		-
Cost estimate accuracy		
Total installed cost		

Table 6: Cost Estimate Details: LMP Programme for RIIO-2 & 3

[3] No studies have yet been concluded on each AGI site that requires upsizing. An estimate of *XXXX* for each AGI upsize has been included based on LMP governor cost estimates for RIIO-1, for the 13 nr AGI's in scope. In addition to these top down efficiencies have been applied.

6.4. Options Summary

Our preferred programme-option for the LMP programme, was agreed during RIIO-1.

Our RIIO-2 & 3 programme comprises delivering the remaining 12 sections of this overall scheme. As part of our RIIO-1 plan, we assessed two programme-options including the baseline option of reactively repairing pipework upon failure. Our RIIO-1 plan proposed a proactive replacement of all identified high-risk mains, primarily using the pipe-insertion method.

A review of each section within the programme, together with the preferred solution options for each is discussed in Appendix 2.

As such the following table summarises the baseline and single, programme-option for the entire LMP scheme. We have undertaken a CBA to demonstrate that this proactive option is still the optimum programme approach. This is discussed in section 7, the approach to our cost benefit analysis is contained in Appendix 5.

	Baseline: Reactively repair upon failure	**Option 1: Proactively replace /renew**
Option description	Allow existing pipes to fail and repair following failure.	Proactively construct proposed LMP scheme
Project start date	N/A	RIIO-1
Project commissioning date		End of RIIO-3
Operating costs		
Total installed cost: Repex	Redacted due to commercial sensitivity	
Total installed cost: Capex		
Cost estimate accuracy noted in %		

Table 7: Programme-options summary

Our RIIO-2 forecasts, as well adjusting for workload and work mix factors also include ongoing efficiencies flowing from our transformation activities, including from updating and renewing our contracting strategies. Our initiatives are outlined in Appendix 09.20 Resolving our benchmark performance gap. For repex activities this seeks a 5% efficiency improvement by 2025/26 on the end of RIIO-1 cost efficiency level. Applying this results in a *XXXX* efficiency over 5 years, to this investment area. All costs in this document are post efficiency.

7. Business Case Outline and Discussion

7.1. Key Business Case Drivers Description

The LMP programme of work started in RIIO-1 is part of a long-term programme to upgrade and replace the majority of the network and abandon certain sections. This work needs to be undertaken due to the assets health and the resultant risk they pose to nearby buildings and in particular their populations. The programme ensures that is implemented in the most cost effective and least disruptive way to residents, workers, businesses and tourists.

Our over-arching objective for RIIO-2 is to deliver the renewal of the assets in the next phase of the LMP programme to meet our customer's and stakeholder's expectations with regards to safety, resilience and value for money. The network is deteriorating and is becoming more and more unsafe due to increasing numbers of failures, analysis of failures shows that there is a 1% per annum deterioration on the assets in scope of LMP. These are requiring more repairs, which is causing more disruption to residents, businesses and tourists. As a result, we have to resolve the safety problems and replace the network using a managed programme of interventions. We started this process in RIIO-1 and need to continue the next phase of work in RIIO-2 and RIIO-3.

The choice of the preferred option within the cost benefit analysis is driven primarily by the benefit of avoiding the risk of a gas explosion leading to fatalities and injuries in central London. This risk is real and significant and justifies the continued investment in replacing the aging network. It is clear, from our modelling of the properties in the area, that the zone has a very wide variety of property types, sizes and uses. This leads to a wide-range of risks and potential consequences.

Our analysis has demonstrated, what we already understand, that depending on where the explosion was to occur, the consequences could be catastrophic in terms of casualties, property damage and disruption. This observation provides the justification to continue the programme through RIIO-2 the potential loss of life is unacceptable.

The over-arching driver for the programme is safety and fully justifies the expenditure. However, there are many additional drivers for this investment case. These include:

- Long-term security of supply to customers
- Reduced risk of property damage, including buildings of national and international importance
- Reduced risk of building contents damage including works of art, historical artefacts and other items
- Less disruption to residents, businesses, workers, commuters and tourists from a gas explosion
- Minimal disruption from the necessary works for the programme through managed phasing of the activities and use of less open cut techniques and more pipe insertion (instead of high cost, high disruption reactive repairs)
- Reduced leakage and emissions
- Reduced repair costs
- Additional capacity and resilience from an upgraded network to that which will meet future requirements and be able to operate at higher pressures
- Value for money to customers through the least cost of delivering the programme

The cost benefit analysis that has been undertaken to support the business case for this programme is discussed in more detail below.

7.2. Supply and Demand Scenario Sensitivities

The business case for this project does not depend on a supply-demand scenario. However, the project will lead to increase resilience in the centre of London and build-in future capacity for London.

7.3. Business Case Summary

As discussed in Section 6, the optioneering for the LMP program was completed in RIIO-1. This concluded that a programme around the inner-city using pipe insertion was the optimum solution to deliver best value to customers.

For completeness, we have updated our CBA analysis of the proposed RIIO-2 scheme, to demonstrate that this proactive programme of work is still cost beneficial over the baseline case.
We have considered the following programme options, with a number of CBA scenarios to test sensitivity.

- **Baseline**: Reactively repair following failure (Once the RIIO-1 investment is complete)
- **Option 1**: Proactive renew prior to failure (RIIO-2 & 3 investment)
- **Option 2**: Proactive option with investment in RIIO-2 only (RIIO-2 costs of option 1)

Our CBA analysis results are summarised below:

Option No.	Option Name	NPV Relative to Baseline	Cost beneficial	Payback Year	RIIO-2 Spend	Ratio NPV to RIIO-2 spend
Baseline	Baseline					
1	Continued Proactive Programme (RIIO-2 and 3)	Redacted due to commercial sensitivity				
2	Continued Proactive Programme (RIIO-2 only)					

Table 8: Results of cost benefit analysis for LMP (£m)

The table below shows the drivers underlying these positive results in more detail.

Option No.	Option Name	PV Expenditure & Costs	PV Environment	PV Safety	PV Other	Total NPV	NPV Relative to Baseline
Baseline	Baseline						
1	Continued Proactive Programme (RIIO-2 and 3)	Redacted due to commercial sensitivity					
2	Continued Proactive Programme (RIIO-2 only)						

Table 9: Breakdown of the results of the cost benefit analysis for LMP (£m)

Option 1 is our preferred option to deliver the entire scheme throughout RIIO-2 and RIIO-3. The positive NPV result for Option 1 is being driven mainly by the safety benefit, which has a net PV of

XXXX over the baseline scenario. Option 2 shows a similar cost benefit, for the RIIO-2 investment only, again, the positive NPV is mainly driven by safety with a net PV of *XXXX*. **Options 1 and 2 are both cost beneficial and demonstrate that continued investment in the LMP programme is viable.**

We recognise that pay back for this project is 2060, however we believe the payback for the project would be sooner in the real world. There are a number of additional items which we have not included in the CBA, if included they would increase the NPV for intervention.

- We have not considered the impact of higher than average property price increases over time, as this is too uncertain to forecast. London house price rises have on average outstripped inflation, and as such it would be reasonable to inflate their value through time.
- We are also aware that many of the building contain articles of extremely high value and of historical importance, i.e. art galleries and museums. Some of these are irreplaceable. We have not tried to quantify the value of these elements in the modelling.
- Any gas explosion would cause significant disruption to the locality affected. Businesses, workers, tourists and commuters would all be impacted for several days or weeks during the clean-up and reconstruction and repairs. These consequences have not been quantified and therefore have not been included in the cost benefit analysis.

The modelling of the safety aspects associated with network is complex considering the significant variations of the properties in the zone. For example, the weighted average occupation densities vary between 26 and 582 for the twelve sections in the RIIO-2 programme. Because of the size and importance of certain properties and the general high-level of people in the zone (both inside and outside buildings), the safety concerns are real and significant. This supports the company's decision that the safety risks are unacceptable and must be addressed through a continued proactive programme of work.

The programme for LMP must go ahead for safety reasons and is cost beneficial.

8. Preferred Option Scope and Project Plan

As detailed in the sections above, the LMP project is an ambitious replacement programme, replacing some of the largest assets operated by Cadent in the city centre of one of the world's busiest cities.

The original RIIO-1 proposal was that the build period for the LMP project was over two eight-year price-control periods. The long build period is required because there are significant engineering challenges to be overcome, as detailed in this paper.

Through this document, several risks have been identified to the LMP project (some of which are detailed in the route solutions in the Appendix 2). In summary they are:

- **Subways:** We have a duty to use utility subways where they exist.
- **Road Space:** Road space in London is at a premium. Where we are required to open cut sections of pipe, finding a route can be challenging.
- **Rotherhithe Tunnel:** TFL have said that they will not allow closure of the tunnel until there are planned works there to repair the tunnel.
- **Liverpool Street Station:** Our assets go under the station in a utility subway at this location.
- **Stakeholder and Customer Impact:** The preferred route of the LMP project goes past very sensitive locations. Careful stakeholder and customer management will be required.

Due to these risks, we cannot deliver the remaining works over the five years of RIIO-2. We are therefore proposing delivery over the ten years of RIIO-2 and RIIO-3.

Given the challenges of delivery on all sections of the project, a degree of flexibility is required in choose which of the remaining works are the most practical to deliver in the RIIO-2 period. We therefore propose that we do not nominate the specific section for RIIO-2 and RIIO-3 in advance, rather we renew the sections we can secure access to. We propose to deliver half of the length for half of the required funding in RIIO-2 from the entire remaining scope of the project.

In summary, our plan is to deliver the following over the next two price control periods. Renewal of 26km of existing asset and the laying of 1km of new asset to complete the project. The project also includes the replacement of several governors. The total cost of the scheme is *XXXX*. For RIIO-2 we are requesting 50% of the investment required - *XXXX* to address 13km of LMP asset. Although the project will span two price controls benefits are released from each section of work as it's completed.

8.1. Preferred Option for this Request

The preferred option for the LMP scheme in RIIO-2 & 3 is Option 1, to continue to proactively renew the pipes in accordance with the proposed RIIO-1 business plan.

The table below details the expected costs of the remaining LMP project in RIIO-2, based on the preferred solution-options for each section of the scheme. Repex costs include mains renewal elements and capex costs include the replacement of governors.

	Cost to complete LMP £m (RIIO2 and 3)
Repex	Redacted due to commercial sensitivity
Associated Capex	
Total Cost	

Table 10: RIIO-2 Cost summary for LMP project.

8.2. Project Spend Profile

At this stage we are assuming a smooth delivery profile over RIIO-2 and 3.

	2021/22	2022/23	2023/24	2024/25	2025/26	2026+
Repex £m			Redacted due to commercial sensitivity			
Capex £m						
Total £m						

Table 11: Project Spend Profile

8.3. Efficient Cost

To develop the costs for the RIIO-2 plan we have used experienced cost estimators who have worked on the RIIO-1 phase of the LMP project. They have developed bottom up costs based on a study of the route considering engineering challenges.

Our RIIO-2 forecasts, as well as adjusting for workload and work mix factors also include ongoing efficiencies flowing from our transformation activities, including from updating and renewing our contracting strategies. Our initiatives are outlined in Appendix 09.20 Resolving our benchmark performance gap. For Repex activities this seeks a 5% efficiency improvement by 2025/26 on the end of RIIO-1 cost efficiency level. Applying this results in a *XXXX* efficiency over 5 years, to this investment area. All costs in this document are post efficiency.

8.4. Project Plan

A detailed project plan across RIIO-2 and 3 is not possible at this stage. We expect the scheme to be completed by 2031. During RIIO-1, we will continue to develop the design and consult with key stakeholders to firm up our plan.

Throughout the delivery of the RIIO-2 and RIIO-3 phases of the project we will continue our engagement programme with stakeholders across London including London Boroughs, the GLA, TfL, Highways agency, and elected representatives in relation to many of its essential business functions including street works activities and decarbonisation strategies. This ensures that there is an ongoing dialogue between stakeholders and a full understanding of agendas and priorities across the Capital.

When Cadent, or a contractor on behalf of Cadent are undertaking street works activity in a London, a bespoke engagement programme is also planned and implemented. The scope of the engagement will be dependent upon the size of the works and the anticipated impact of the disruption.

Typically, engagement activity includes; pre-engagement with all affected parties, including the London Borough, TfL and the Highways agency; coordination meetings with Westminster/TfL/police/key stakeholders to consider transport and environmental impacts; briefings for political and community representatives, public exhibitions; mail drops, press releases and digital communications using geo-targeting.

8.5. Key Business Risks and Opportunities

The significant risks are as follows:

Reference	Risk Description	Impact	Likelihood	Mitigation /Control
09.06 - 001	Supply & Demand deliverability risk of Resource availability within the Gas industry	Potential cost increases in labour / commodity markets as demand is greater than supply	Low	Intelligent procurement and market testing. Apprenticeship and Training programmes to fill skills gaps
09.06 - 002	Stretching efficiency targets may not be deliverable (unit costs increase)	Outturn costs are not met increasing overall programme costs.	Medium	Established market place - ability to manage the known commodity market
09.06 - 003	Unforeseen outages and failures restrict access for planned work	Programme and delivery slippage due to delay of planned outages and or site access	Low	Proactive asset management with ongoing condition surveys and response plans to prevent failures
09.06 - 004	Unseasonal weather in 'shoulder months', Autumn and Spring reduce site access/outage windows	Increased demands affecting access to sites and planned outages delay and cost increases	Low	Controlled forecasting and maintenance of flexibility to react to unforeseen events. Detailed design solutions to minimise outages and reduce exposure.
09.06 - 005	Unexpected / uncommunicated obsolescence during RIIO-2 period of equipment components	Inability to maintain equipment at full capacity with risk of impact upon supply	Low	Maintain a close relationship with equipment supply chain and manage a proactive early warning system where spares / replacements become at risk.
09.06 - 006	Legislative change - There is a risk that legislative change will impact the delivery of our work.	Potential increase in the amount of consultation and information exchange required and require us to align our plans with the safety management processes operated by 3rd Party landowner / asset owners. The potential impact is more engagement and slower delivery	Med	We have established management teams to address these issues. We have also identified UMs for key areas.

Reference	Risk Description	Impact	Likelihood	Mitigation /Control
09.06 - 007	Availability of skilled labour and local cost increases in London weighted zones	Failure to meet programme delivery and cost profiles on London based projects	Low	Intelligent procurement and market testing. Apprenticeship and Training programmes to fill skills gaps
09.06 - 008	Increased external constraints - To carry out this work we depend on the acceptance of multiple stakeholders. There is a risk that obtaining consents proves to be more difficult than expected slowing work output.	Reduced amounts of proactive work delivered and no or reduced improvement in customer restore time after interruption due to delayed reactive work.	Med	Our management team are tasked with improving engagement and the production of RAMS that seek to overcome these issues.
09.06 - 009	Escalating costs due to the complex engineering for technical solutions for replacing mains in subways	Technical solutions for replacing mains in subways - increased costs and programme delays	Med	Managing the design process and reducing impacts through the supply chain and stakeholder engagement

Table 12: Risk Register

This paper proposes a plan which covers 50% of the remaining project. However, we need the option to select from 100% of the remaining assets as there is difficulty in securing access to the assets which are dependent on TFL, Local Authorities or others granting permission.

We are therefore proposing that this project be included in a PCD mechanism for the investment, which will allow us to mitigate any significant deviation from our allowed volumes.

8.6. Outputs Included in RIIO-1 Plans

The spend detailed in this paper does not include any outputs that will be realised in RIIO-1.

9.0 Regulatory Treatment

Our London Medium Pressure programme in RIIO-2 will deliver the renewal of 50% of the remaining assets in scope of the pressure project, in the heart of our nation's capital. We propose that this programme should be treated as a price control deliverable within the RIIO-2 framework. We have proposed this approach as it is of high value and the funding would not be transferrable to a different output or project to deliver the same outcome for our London customers.

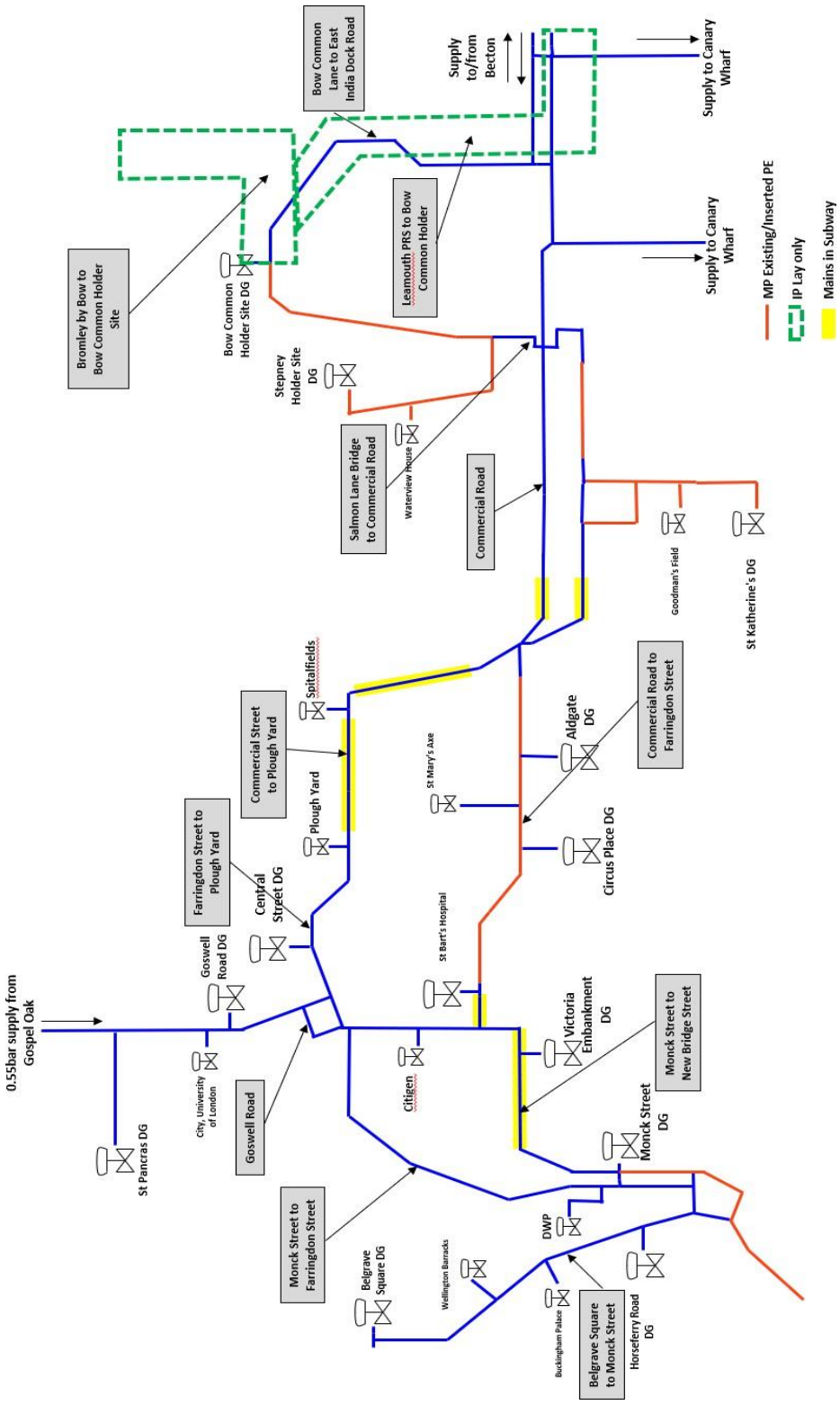
We are proposing a specific PCD for the London medium pressure scheme given its challenging access requirements and interaction with other infrastructure developments and a totex sharing factor of 15% recognising the lower confidence in costs at this stage of its development.

Given the ringfenced nature of this project and uncertainty of outturn costs (estimate +-35%) we propose that this is treated separately as its own PCD and not included as part of the blended sharing factor as this will give the best protection customers. The costs for this project are easily ringfenced as it is contracted and delivered separately so all direct costs and direct overheads are fully applicable. We would propose that to maintain the integrity of totex sharing factors that no indirect overheads are included in the PCD (our business support costs for example).

Whilst the funding would not be transferable to a different output or project utilising a PCD does provide flexibility and incentives for us to innovate and drive efficiencies in delivering this project. We commit that throughout RIIO-2 we will continue to engage with stakeholder to re-assess the most efficient way of delivering these outcomes for our London customers. Where a more efficient approach is identified we will engage with Ofgem to ensure they understand how the alternate approach still delivers the desired outcome.

This investment is accounted for in the Business Plan data Table 4.30 repex mains Tier 2B & 3.

Appendix 1. Location Map



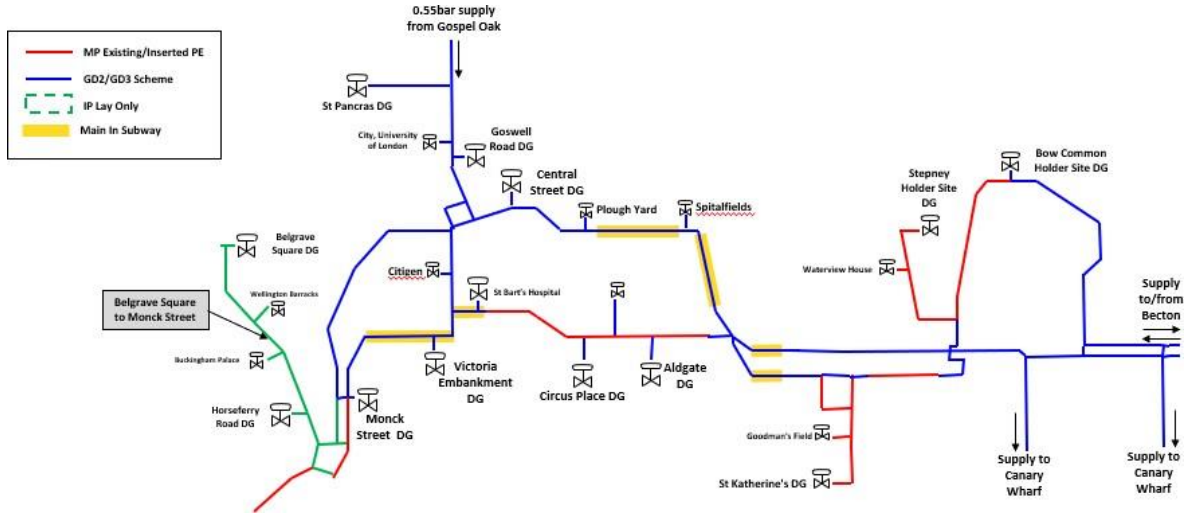
Appendix 2. Solution Options

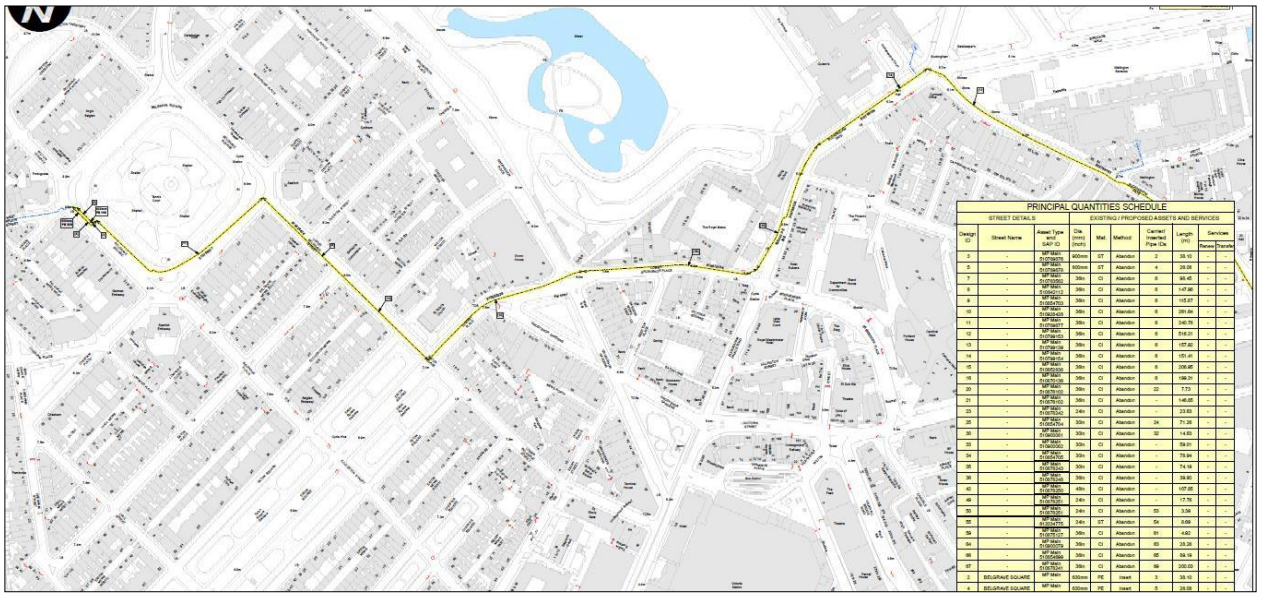
The remaining sections of the LMP scheme for design and construction during RIIO-2 & 3 comprise 12 individual sections. This Appendix discusses the preferred solution-options for each section.

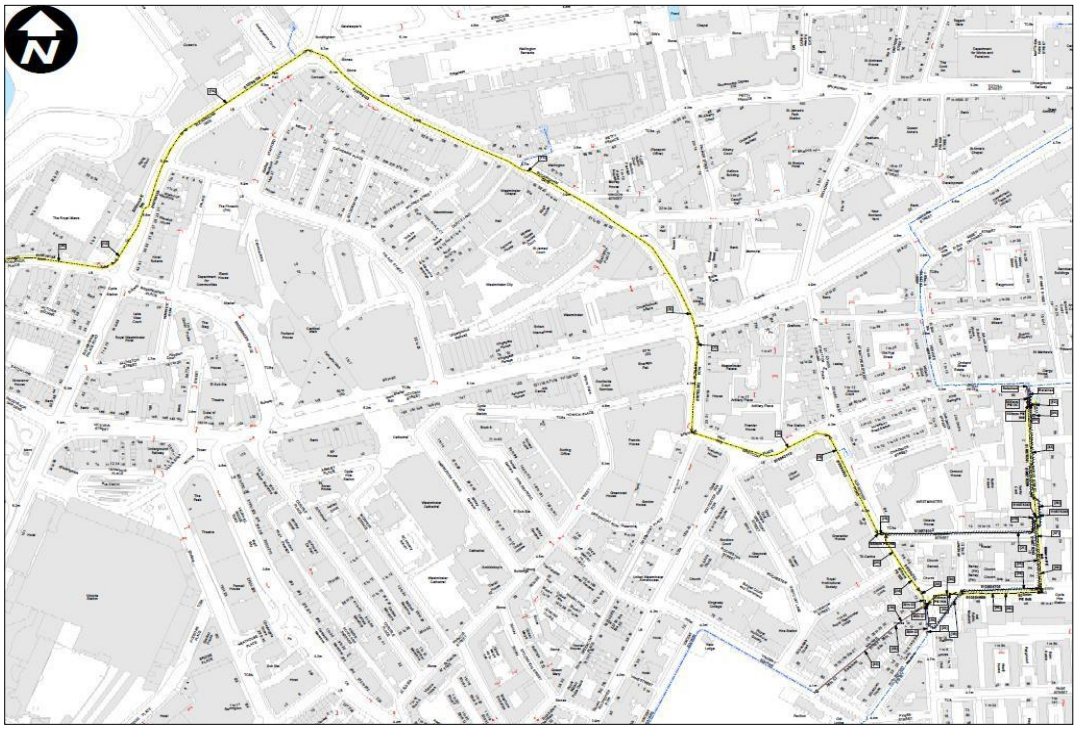
Section	Assets within scope of RIIO-2 scheme
1	Belgrave Square to Monck Street
2	Salmon Lane Bridge to Commercial Road
3	Commercial Road to Farringdon Street
4	Commercial Street to Plough Yard
5	Farringdon Street to Plough Yard
6	Goswell Road Abandonment
7	Commercial Road Abandonment
8	Bromley by Bow to Bow Common
9	Bow Common to East India Dock Road
10	Monck Street to Farringdon Road
11	Monck Street to New Bridge Street
12	Farringdon Street

Section 1. Belgrave Square to Monck Street

This section is comprised of 2.9km of 36” diameter cast iron pipework along a street with bus lanes passing Buckingham Palace.







Various intervention options have been reviewed but, as we already have a suitable asset that can act as a carrier, insertion is the preferred renewal technique. This is the least disruptive and cheapest option.

Previous experience in Brompton Road has suggested that push lengths will likely be restricted in the area. For the remaining 2,757m we have assumed that there will be a further seven isolations (average every 394m). This has been forecast by identifying suitable points to isolate at specific locations that will require maintaining/ swapping over. This includes but is not limited to *XXXXXXXXXXXXXXX*, Horseferry Road, Medway Street and Monck Street. The frequency of bends has been factored into the assumed number of insertion pits required. The majority is believed to be insertable with an allowance for 100m Open-Cut at pinch points. Please note that we have not included target costing for the replacement of Mounsel Street to Monck Street as this has been let under RIIO-1 programme.

Three district governors are situated along this section: Belgrave Square, Horseferry and Monck Street. The route also includes one high-value meter point (Buckingham Palace).

Along this section of the work, there are no assets that are located within utility subways.

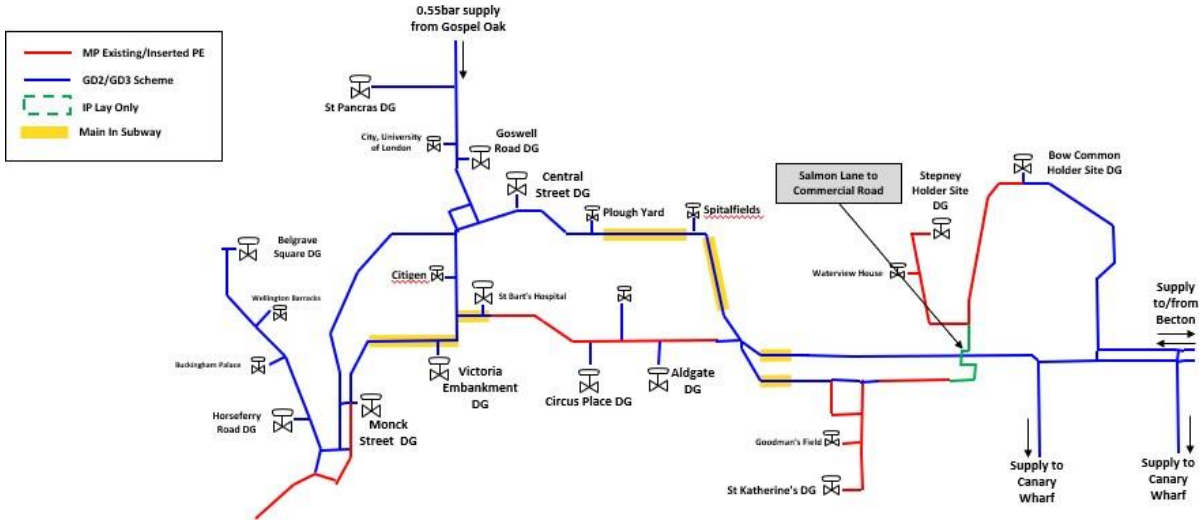
The proposed scope of work for Belgrave Square to Monck Street in RIIO-2 is:

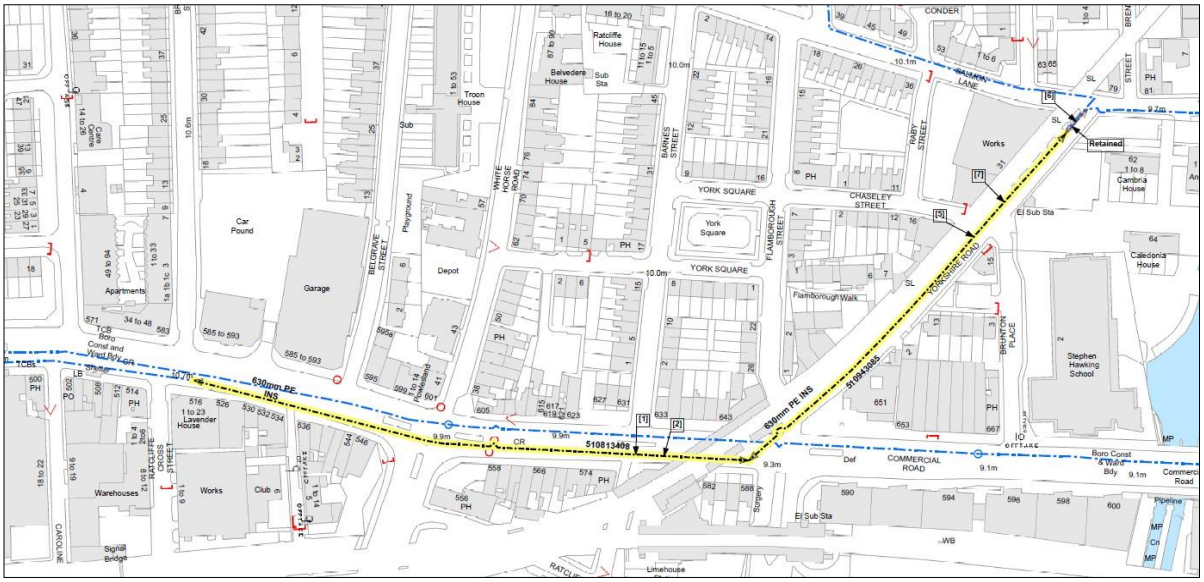
- Abandon the existing 2.9km of 36” CI pipe
- Insert new MP pipe 2.9km
- Replace three district governors

Once this section is complete, Cadent can elevate the London West Network to the Monck Street district governor to 2 barg, adding resilience and allowing continuation of LMP works into Central/ East London.

Section 2: Salmon Lane to Commercial Road

This section is comprised of 0.6km of 36” diameter cast iron pipework from Salmon Lane Bridge to Commercial Road.





The asset is located in the highway near the busy junctions of the Rotherhithe Tunnel approach. There are two train stations either side of the junction. The route will need considerable traffic management due to the location.

Commercial Road to Salmon Lane has been presumed as three phases, picking up on the valve left at the completion of a previous phase, 1 bagstop operation and the remaining being isolations associated with existing valves. We have included for further excavation (4 of the 7 insertion pits) allowances as there will likely need to be a set of shafts and headings to negotiate the Commercial Road crossing. Traffic management has also been doubled for the assumed rate per metre to allow for significant complexities associated with diverting at this area (vicinity to Rotherhithe tunnel).

There is one district governor fed indirectly by this section, Stepney Holder.

Along this section of the work, there are no assets that are located within the utility subways.

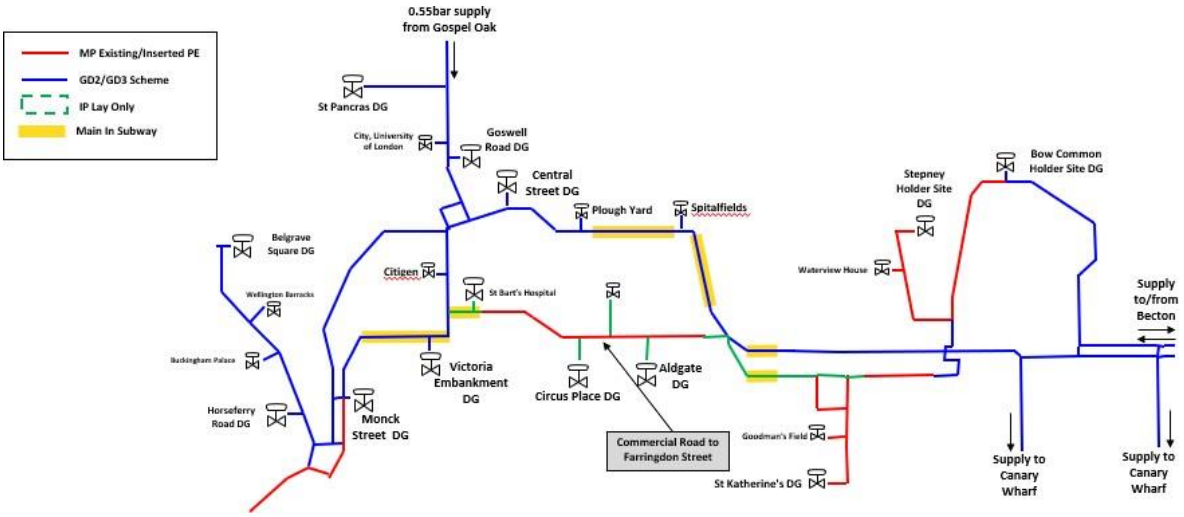
The proposed scope of work for RIIO-2 is therefore to:

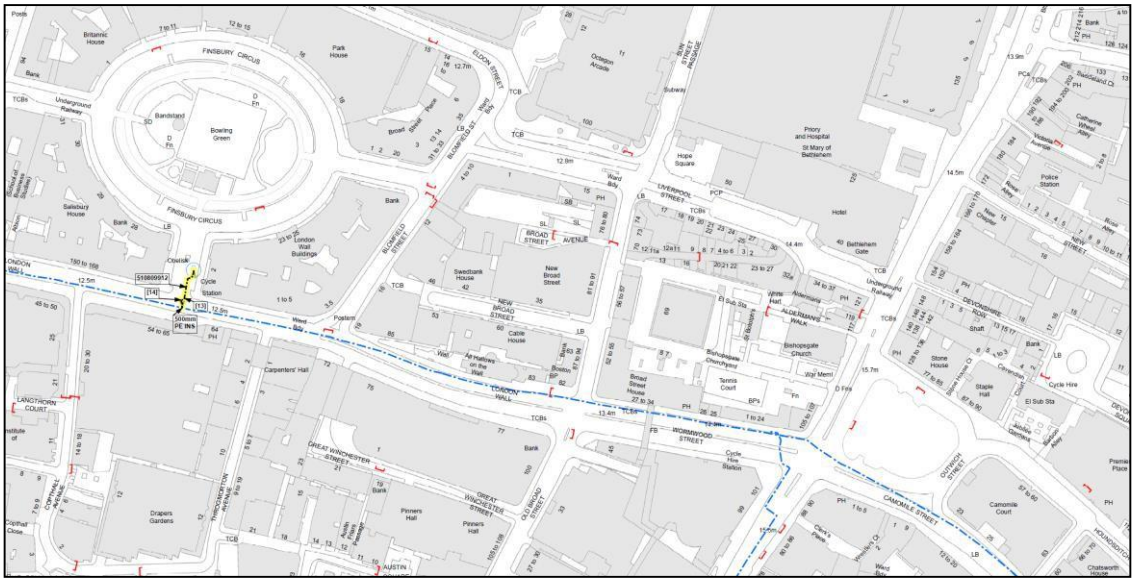
- Abandon the existing 0.6km of 36” CI pipe
- Insert new MP pipe 0.6km
- Replace one district governors

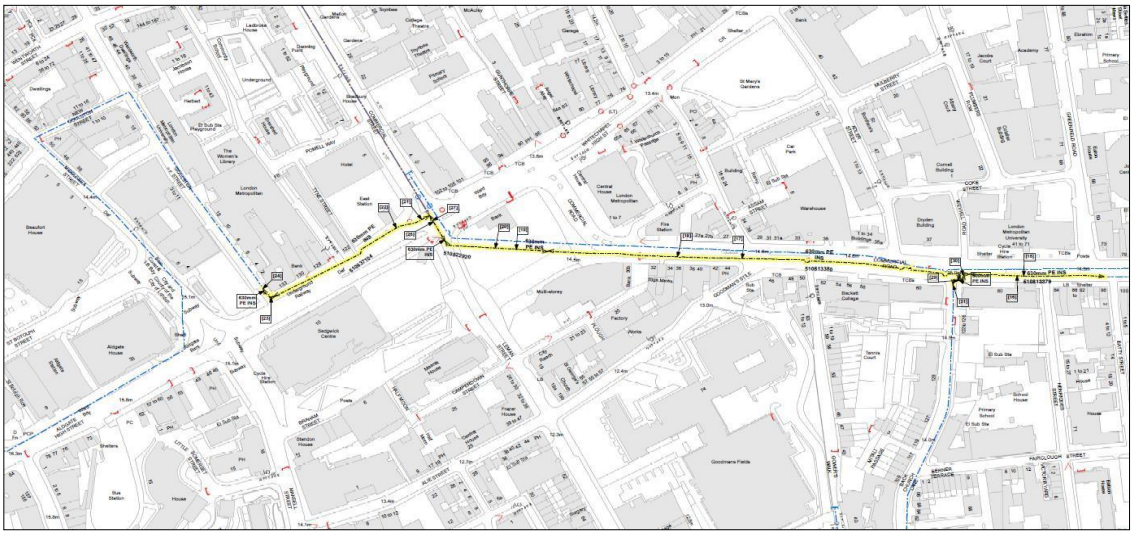
Difficulties and risks associated with route: Rotherhithe Tunnel closure will be required as part of the traffic management. A number of bends on the 48inch main are located in the carriageway on the tunnel approach road. Thus, excavation is required to remove the bends and allow for the new MP pipeline insertion. TFL have said that they will not allow closure of the Rotherhithe Tunnel until there are planned works there to repair the tunnel. Time scales have not been made available.

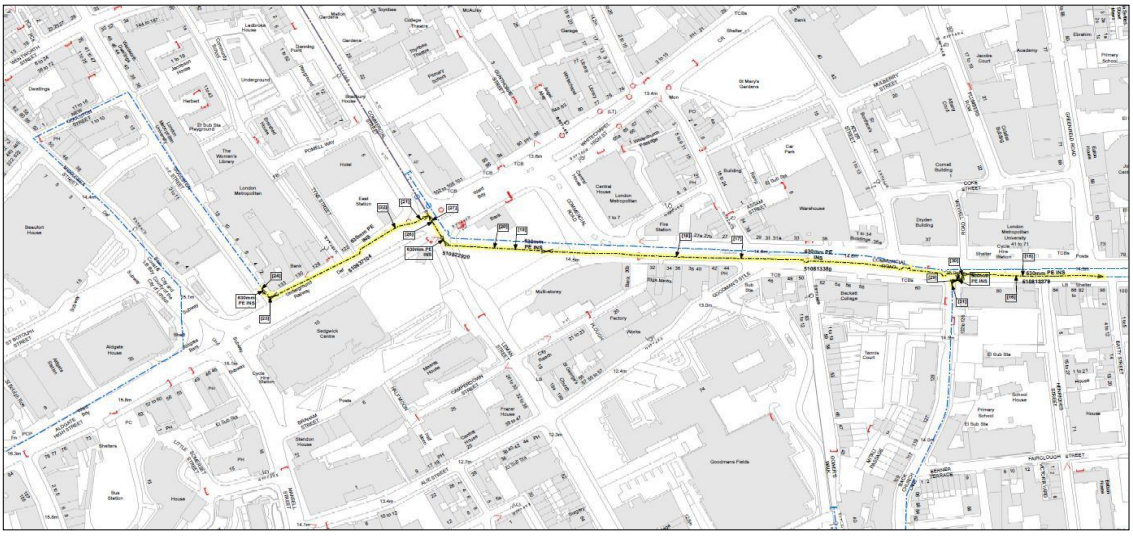
Section 3: Commercial Road to Farringdon Street

This section is comprised of 1km of 36” diameter, CI pipework, of which 570 meters of this is located with two utility subway ways.









Certain sections of this route have already been replaced as part of the RIIO-1 workload; thus, only the remaining 1km is to be replaced. On completion, this route will become the main link connecting the west side of the network to the east side of the network. The A13 commercial road is a strategic route linking Essex/ London east with central London, so it will need considerable Traffic management.

Commercial Road to Farringdon Street contains several complexities surrounding mains contained within subways. The main at Holborn Viaduct is contained in the subway system and drops to from the bridge to the street underneath (Farringdon Street). To negotiate access issues and tie in the mains at either end, we have had to assume (using feedback from Estimating teams) an average rate of *XXXX* per metre to resolve these issues. Outside of these special engineering difficulties, we have again used likely/suitable points of isolation and insertion.

Three governors are situated along this section, these are Circus Place, Aldgate and St Barts. There are also two off takes on this section of main, feeding St Bart's and Bishopsgate development meter points.

Along this section of the work, there is 570 meters of assets located within the utility subways: Holborn Viaduct 220 metres of 36" CI pipe and Commercial Road 350 meters of 48" CI pipe.

The proposed scope of work for RIIO-2 is therefore to:

- Abandon the existing 1 km of MP CI pipework
- Insert new MP pipe 0.43km

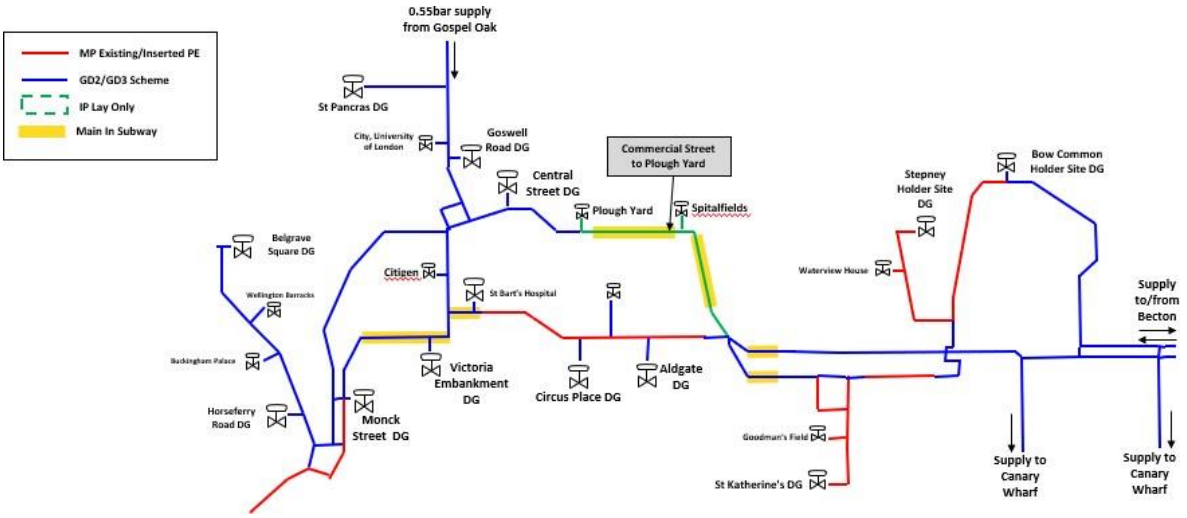
- Replace 0.57km of subway mains via insertion or open cut
- Replace three district governors

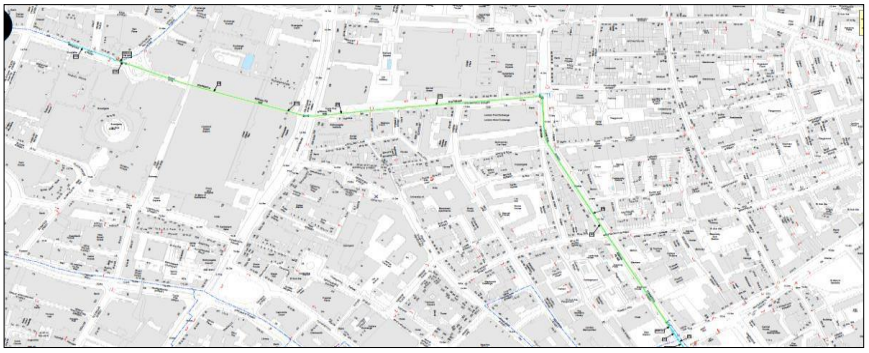
Difficulties and risks associated with route: There will need to be traffic management on busy roads. If no subway solution can be found, agreement with the Local Authority will be required to lay in the highway. However, an open cut route is not guaranteed, as London streets are already congested.

There are sections of this main that sit within the surrounding wall of the tube line. This poses difficult engineering challenges that will need to be addressed.

Section 4: Commercial Street to Plough Yard

This section is comprised of 1.1 km of 36” and 48” diameter, CI pipework, of which 650 meters of this is located with two utility subway ways.





Commercial Street to Plough Yard encounters issues at the junction of Whitechapel High Street associated with the subway and London Underground. To negotiate these issues, again we have assumed a rate per metre, which broadly considers access to the subway (safety/egress etc.), accessing the main within the subway, moving plant contained in the subway, finding a suitable push location and undertaking the works. The significant cost is due to the large volume of main located in these areas (565m).

The proposed scope of work for RIIO-2 is therefore to:

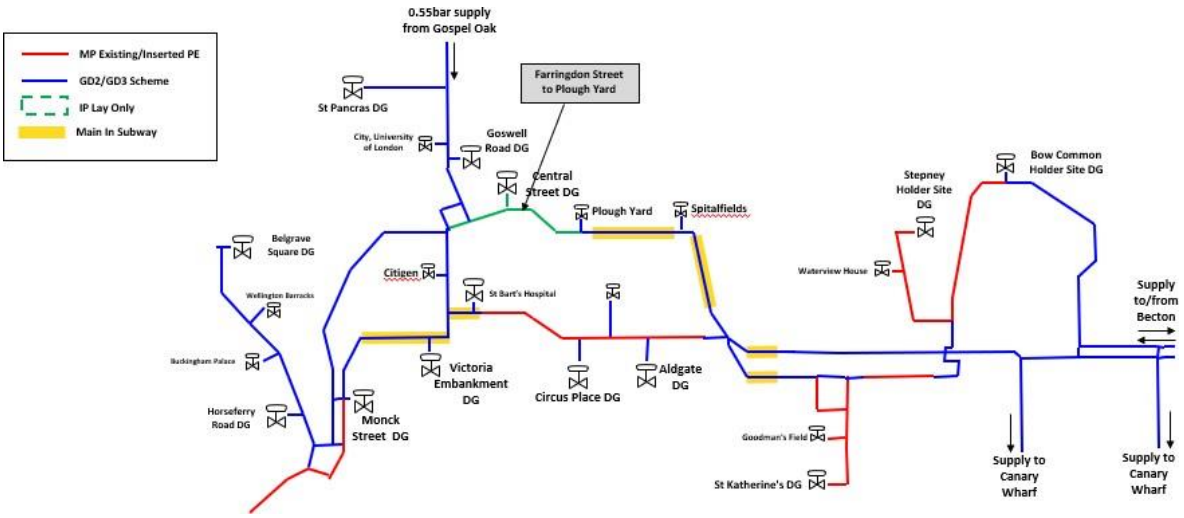
- Abandon the existing 1.1km of MP CI pipework
- Insert new MP pipe 1.1km

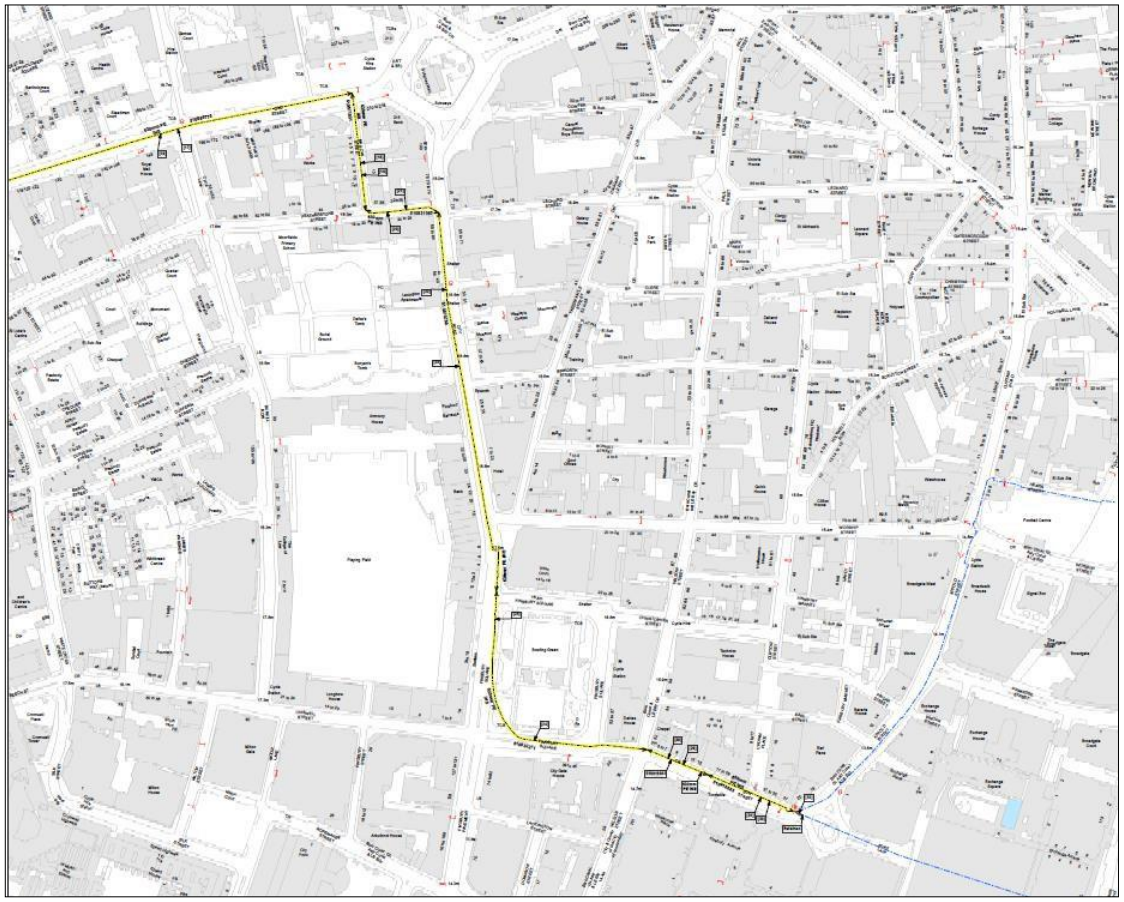
Difficulties and risks associated with route: There will need to be traffic management on busy roads. If no subway solution can be found, agreement with the Local Authority will be required to lay in the highway. However, an open cut route is not guaranteed, as London streets are already congested.

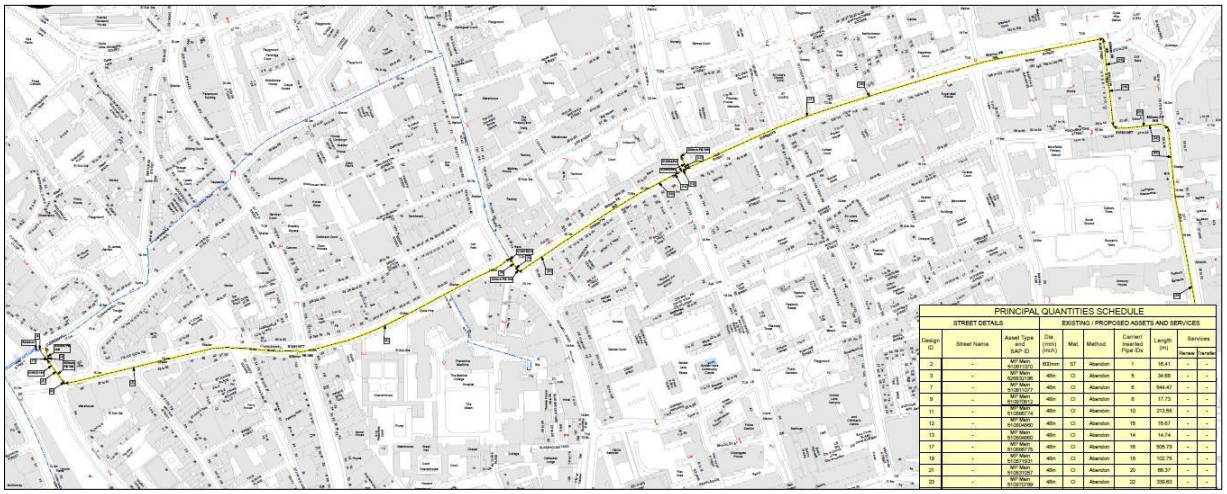
Additionally, one of the utility subways goes under Liverpool Street Station.

Section 5: Farringdon Street to Plough Yard

This section is comprised of 2.3 km of MP, CI pipework,







There is one district governor situated along this section. Along this section of the work, there are no assets located within the utility subways.

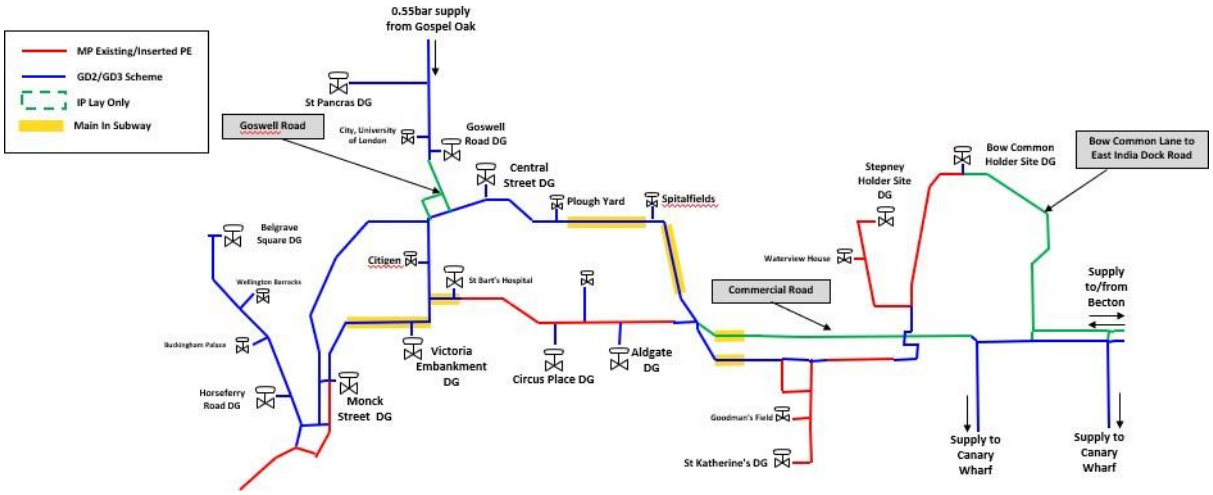
Farringdon Street to Plough Yard assumes four sets of isolations, averaging push lengths of 500m. Insertion pits have again been considered at bend/pinch points on the works. Lane rental has been identified at the junction of Clerkenwell and assumed for 7 days at duration of 16 weeks.

The proposed scope of work for RIIO-2 is therefore to:

- Abandon the existing 2.3 km of MP CI pipework
- Insert new MP pipe 2.3 km
- Replace Central Street DG

Difficulties and risks associated with route: There will need to be traffic management on busy roads.

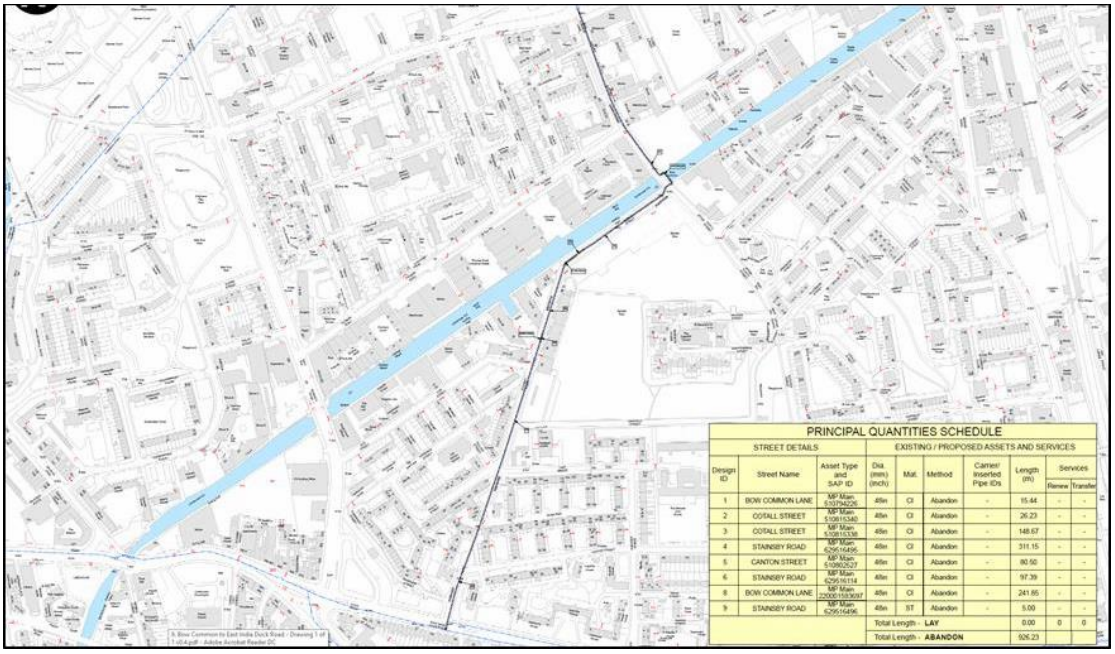
Section 6/7/9: Bow Common Lane to East India Dock Road, Commercial Road and Goswell Road



These sections are 'abandon only'; therefore, the proposed scope of work for RIIO-2 is to:

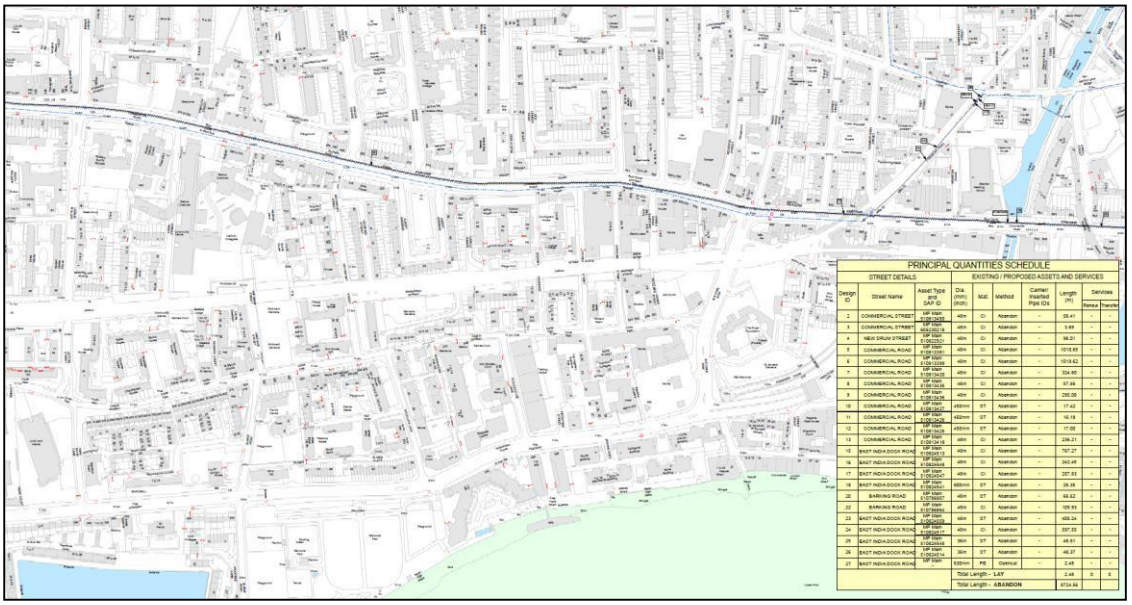
1. Abandon the existing 0.9 km of pipe from Bow Common Lane to East India Dock Road

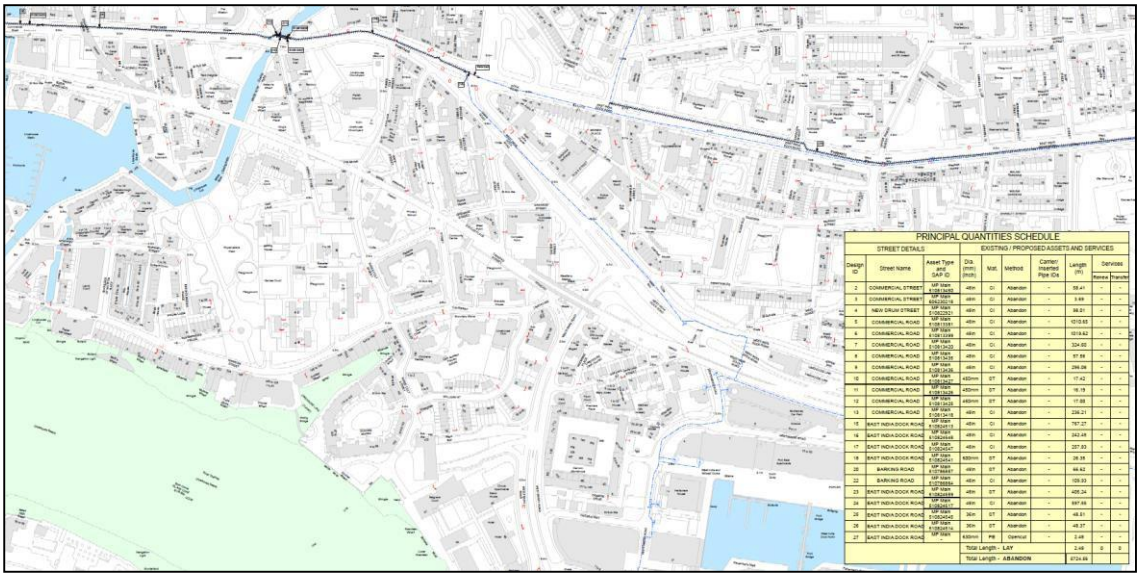
   Isolations have been considered at the top end of Bow Common Lane and the two MP mains at East India Dock Road. Allowances have been made for the installation of valves. 20m has been allowed for the connection of the two mains at East India Dock Road.

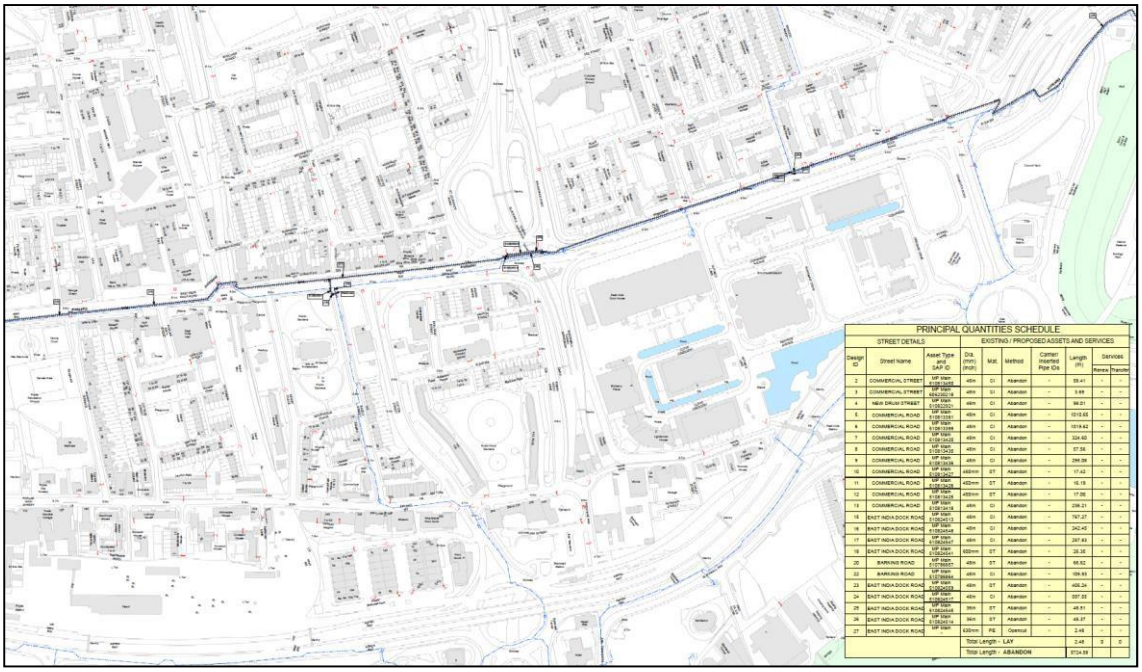


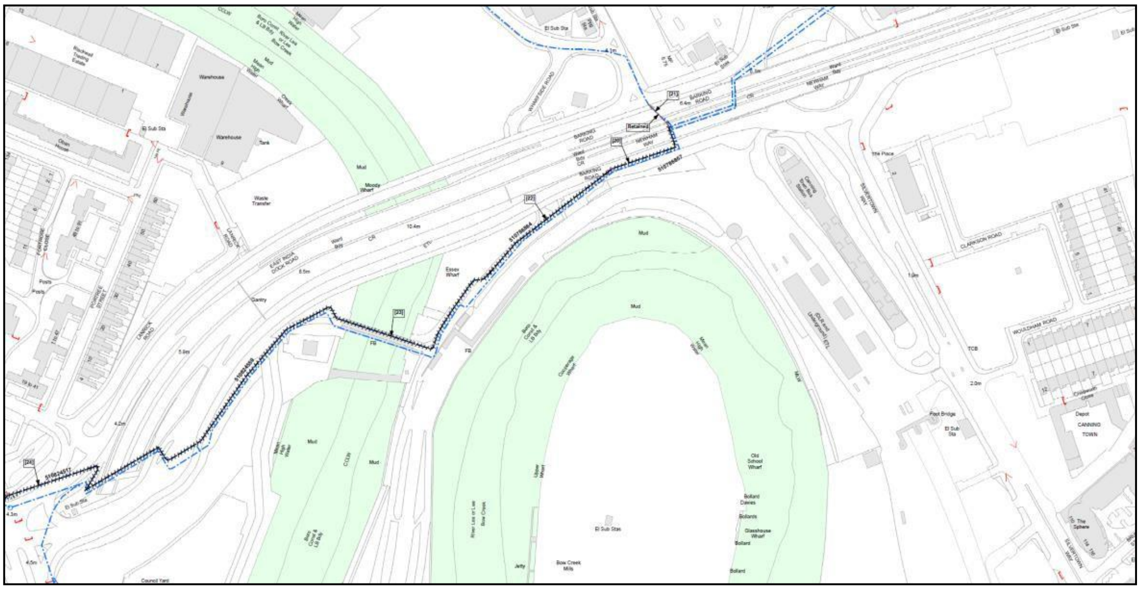
2. Abandon the existing 6 km of pipe in Commercial Road

Commercial Road abandonment has identified the requirement for 5 stopples at connection points along the route of the abandonment as well as complex activities surrounding the subway (30m approx.). Pipe and fittings assumptions remain for the purchase and installation of valves at the isolation points. Lane rental at the locations have also been forecast. There is one district governor associated with this route, Poplar Grid.



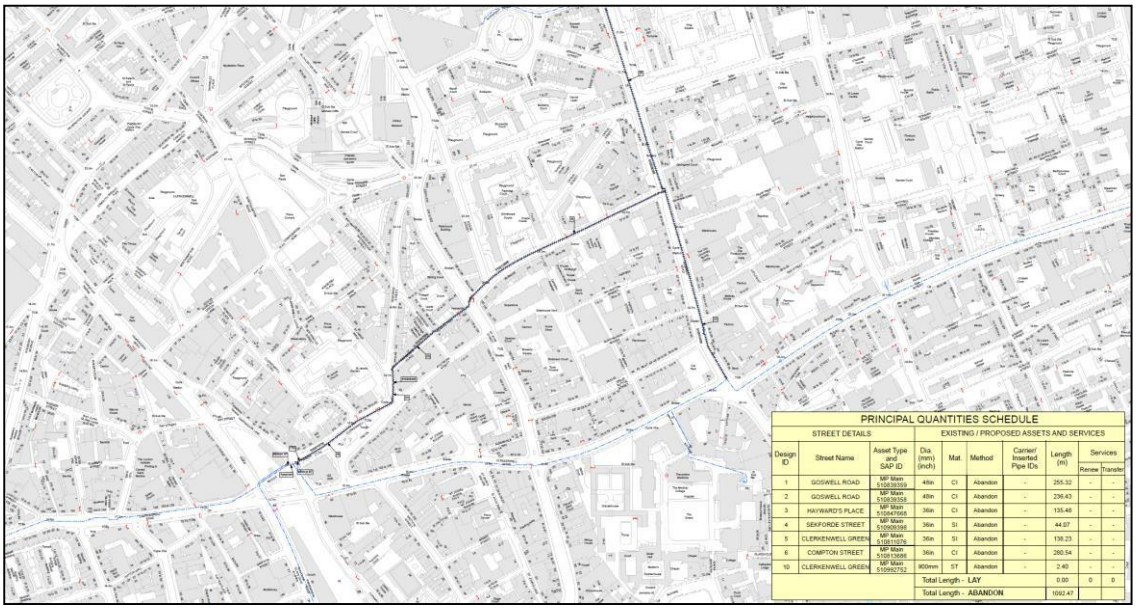

PRINCIPAL QUANTITIES SCHEDULE
STREET DETAILS
EXISTING / PROPOSED ASSETS AND SERVICES
Design ID
Street Name
Asset Type and SAP ID
Dia (mm) (inch)
Mat.
Method
Carrier Inserted Pipe Dia
Length (m)
Services
Renew
Transfer
COMMERCIAL STREET
NEW DRUM STREET
COMMERCIAL ROAD
BARKING ROAD
EAST INDIA DOCK ROAD
Total Length - LAY
Total Length - ABANDON


PRINCIPAL QUANTITIES SCHEDULE
STREET DETAILS
EXISTING / PROPOSED ASSETS AND SERVICES
Design ID
Street Name
Asset Type and SAP ID
Dia (mm) (inch)
Mat.
Method
Carrier Inserted Pipe Dia
Length (m)
Services
Renew
Transfer
COMMERCIAL STREET
NEW DRUM STREET
COMMERCIAL ROAD
BARKING ROAD
EAST INDIA DOCK ROAD
Total Length - LAY
Total Length - ABANDON



3. Abandon the existing 1.1 km of pipe in Goswell Road

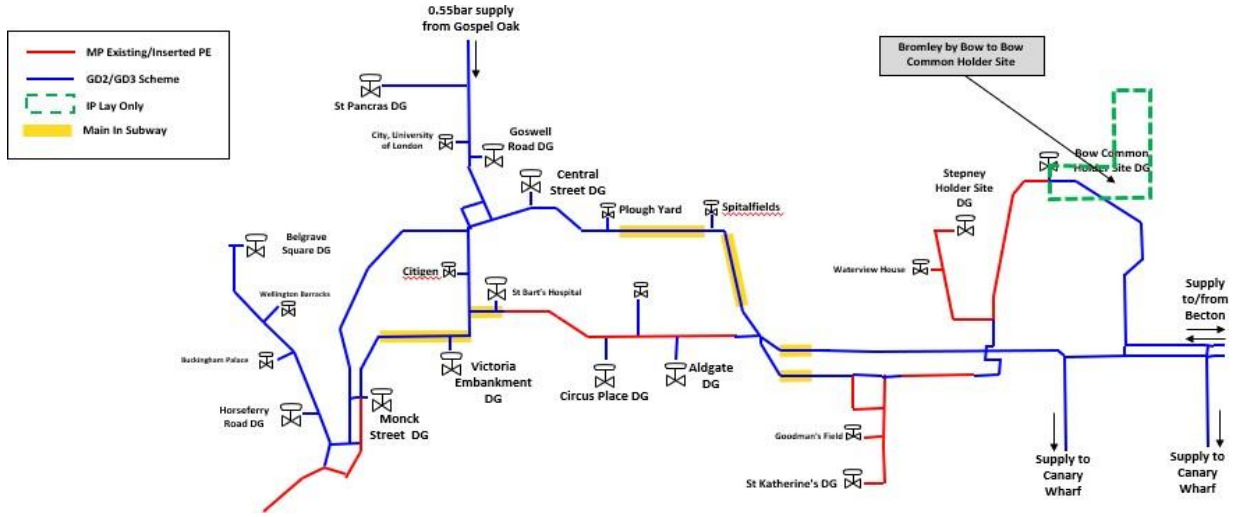
   Goswell Road has assumed three isolations to undertake. An insertion pit has been allowed for associated with the retained steel outside. Due to locations of isolations, lane rental has been included.

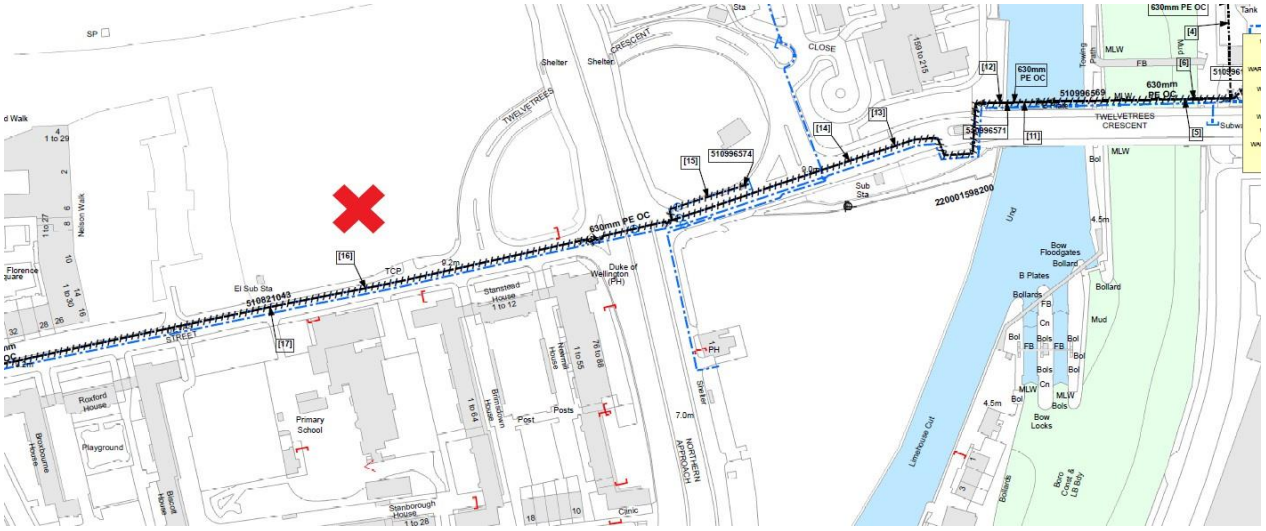


PRINCIPAL QUANTITIES SCHEDULE

STREET DETAILS			EXISTING / PROPOSED ASSETS AND SERVICES						
Design ID	Street Name	Asset Type and SAP ID	Dia. (mm) (inch)	Mat.	Method	Carrier/ Inserted Pipe IDs	Length (m)	Services	
								Renew	Transfer
1	GOSWELL ROAD	MP Main 5108393S9	48in	CI	Abandon	-	255.32	-	-
2	GOSWELL ROAD	MP Main 5108393S8	48in	CI	Abandon	-	236.43	-	-
3	HAYWARD'S PLACE	MP Main 5108476S8	36in	CI	Abandon	-	135.48	-	-
4	SEKFORDE STREET	MP Main 5109093S8	36in	SI	Abandon	-	44.87	-	-
5	CLERKENWELL GREEN	MP Main 5108110S8	36in	SI	Abandon	-	138.23	-	-
6	COMPTON STREET	MP Main 5109119S8	36in	CI	Abandon	-	260.54	-	-
10	CLERKENWELL GREEN	MP Main 5109927S2	900mm	ST	Abandon	-	2.40	-	-
			Total Length - LAY				0.00	0	0
			Total Length - ABANDON				1092.47		

Section 8: Bromley by Bow to Bow Common Holder





During the RIIO-1 phase of the LMP project, renewal of the network to Bow Common has been completed. In addition, as part of National Grid works, the Bow Common site is being refurbished and new governors installed which are to LMP specification.

The undertaking of this IP installation will pose a significant challenge. The solution has been identified as a tunnel from Bromley By Bow holder site to a suitable reception location identified as opposite the primary school (shown with red X above), this is forecast to be 505m in length. We have pro rata'd the cost per metre of Thames Tunnel (carried out in RIIO-1) to this project.

A significant amount of steel is also expected on the project and this has been factored into pipe and fittings allowance. The complexity of the works means that significant CAD drawings and trial holes will also be required for the new open cut route. As the main will also be IP, the testing times have been specifically adjusted to account.

To connect to the Bow Common Holder Site, the preferred route, the reinforcement of an existing intermediate pressure (IP) main between Bromley by Bow to Bow Common holder site is required. The new IP main can be inserted within the existing 48" MP main for approximately 600m. An additional 800m of open cut is required along Devons Road to connect into the site.

As part of this route, a new IP main is required to cross the DLR tracks outside Devons Road Station, and a feasibility study was carried out to explore options for a below-ground tunnel for the main. However, further work is required on this to consider options to use the existing bridge deck or install a new exposed crossing. The feasibility can be found in Appendix 4.

This route requires one strategic governor.

The proposed scope of work for RIIO-2 is therefore to:

- Abandon the existing 600m of 48” MP CI pipe
- Insert new IP pipe 600 meters
- Open cut 800 meters
- Connect to New Bow common holder PRS

Difficulties and risks associated with routes: London streets are congested with third party utilities; thus, it might be difficult to obtain sufficient road space for a new pipeline.

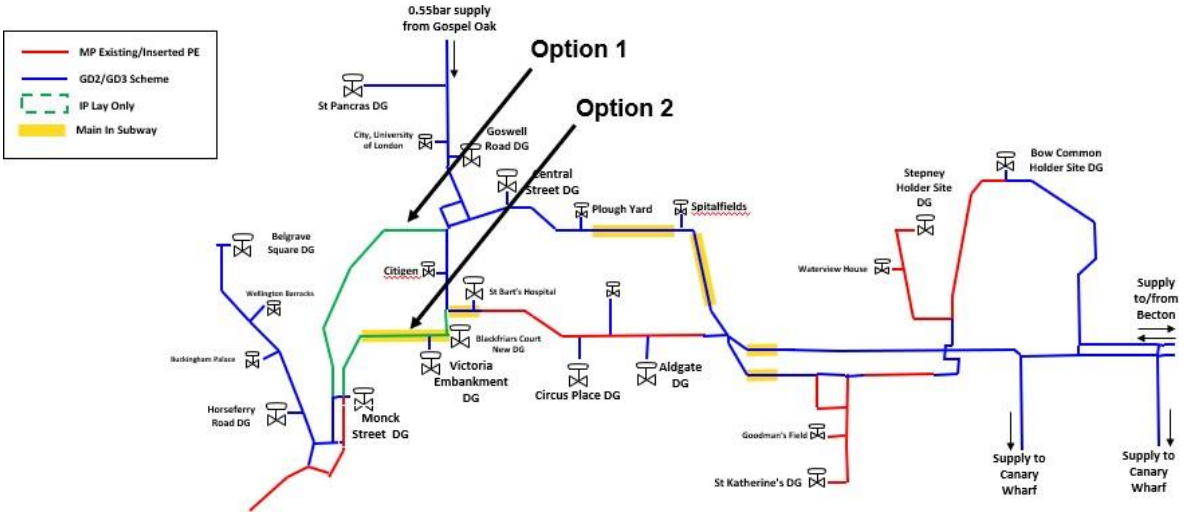
Above-ground Thames River crossings at Twelvetrees Crescent: Currently there is a twin 48” MP above crossing, this work will require one of the mains to be upgraded to IP. Twelvetrees Crescent is currently under planning review for development of the site by NG properties.

Section 10 & 11: Route from Monck Street to Farringdon Road or New Bridge Street

For this section of the LMP project, starting at Monck Street, there are two fundamentally different routes and solution-options to be considered, both following the routes of existing pipes.

The following section of the document therefore sets out the solution and route options considered for the Monck Street element of the London Medium Pressure scheme. As stated above there are two options that follow the path of existing assets, the location and extent of these options are show in the diagram below:

- **Option 1:** Monck Street to Farringdon Street
- **Option 2:** Monck Street to New Bridge Street



Both routes have significant challenges associated with them, a summary of the most significant ones is listed below:

- **Subways:** The Victoria Embankment subway is the longest utility subway in scope of the LMP project at 2.3km in length. This presents delivery challenges as the only option is to gain access into the subway to install a new steel main, this would require extensive works to open the subway.
- **Operating Windows:** The two options have different operating windows in which renewal activity can take place. Shorter operating windows slow down delivery as delivery teams cannot work all year round.
- **Stakeholders:** The Monck Street to Farringdon Street route goes through the heart of the city including Trafalgar Square and the Theatre District. Careful stakeholder management will be required to ensure business and customers and not detrimentally impacted.
- **Thames Tideway:** Other major infrastructure work in London impacts on the deliverability of the LMP scheme. This limits our ability to get road space access where required, impacting on the pace of delivery.
- **Network Resilience:** The two route options have different resilience risks associated upon completion as different configurations of the network will have differing resilience

Figure 5: Monck Street to New Bridge Street and Monck Street to Farringdon Street Routes

characteristics.

Section 10: Option 1: Monck Street to Farringdon Street

The following table summarises some of the key features, risks and issues with this option.

Scheme feature	Description
Subways	The Monck Street to Farringdon Street route goes via a 220m utility subway, the Monck Street to New Bridge Street also needs to go via this utility subway. The Subways Act 1893 which puts a requirement on the business to use the utility subways in London where they exist. The only safe engineering solution for laying new pipes in subways is to install new steel mains. To install new mains in subways requires significant works to get access to lay the pipe. It is only possible to open cut alongside the subways where there is sufficient business justification to do so and this is agreed with the Local Authority.
Operating Windows	Operating windows: The Monck Street to New Bridge Street route has the benefit of having a 100% operating window which will allow delivery teams to work year-round. Year round working would enable to risk of delivery to the proposed time scale less risky.
Access	In addition to the traffic disruption that we would expect with working in the centre of London, the Monck Street to Farringdon Street route goes through the heart of the city, passing major landmarks and the Theatre District. Major stakeholder engagement will be required to limit the impact of the work.
Resilience	The Monck Street to Farringdon Street offers the best option in respect to network resilience. By installing regulators at two new sites (one at Bloomsbury Square Gardens and another at Blackfriars Court, to replace the site at Victoria Embankment), supply resilience (multiple outages before disruption) of the LP network can be improved on a long-term basis. However, this would be subject to the procurement of land. If the assets on either of the routes were to have a failure in the future, and it needed to be isolated for repair, the number of customers that would be impacted is given in the table below:

Route Used	Average Scenario	Peak Day Scenario
Monck Street to Farringdon Street	250	11,000

Table 13: Customers Impacted in Event of a Failure

Table 14: Section 10: Option 1: Discussion

The costs for this option are summarised below (note the costs include the abandonment of the Monck Street to New Bridge Street section):

Item	Option 1 Monck St to Farringdon St
Engineering Design	
Project management	
Materials	
Main Works Contractor	Redacted due to commercial sensitivity
Specialist Services	
Vendor Package costs	
Direct Company Costs	
Indirect Company Costs	
Contingency	
Total Installed Cost	
Cost Estimate Accuracy	

Table 15: Section 10: Cost estimate

Section 11: Option 2: Monck Street to New Bridge Street

The following table summarises some of the key features, risks and issues with this option.

Scheme feature	Description
Subways	The Monck Street to New Bridge Street route goes via the Victoria Embankment utility subway, which is 2.3km long. The utility subway was constructed between 1865 and 1880 at the same time as the underground railway and sewage network; it was built to house gas and water utilities and has subsequently been used for telecom utilities. As discussed above the subways act puts a requirement on the business to use the utility subways in London where they exist. Getting access to our assets in the Victoria Embankment subway is particularly challenging as it is through small access routes. The vaulted brick roof cannot be penetrated without significant civils work. The cost of breaking into the subway can be estimated from the Thames Tideway breakout project that was completed in RIIO-1 to support the Thames Tideway project. The cost for a single 20m breakout was *XXXX* which equates to *XXXX* if we were to break into the entire length of the subway, this cost does not include the cost of the gas diversion in steel or any designers' fees or utility diversions, which could be substantial. In addition, our assets are at the bottom of the subway, with more recently installed power cables and fibre-optic telecoms (e.g. the City of London banking circuits) above them restricting access.

Scheme feature	Description
	 *Figure 6: Assets Located in the Victoria Embankment Utility Subway* In addition to the limited operating windows associated with the Victoria Embankment, there is uncertainty regarding the condition of the sewer system on which the subway sits. If an insertion solution for subways is agreed, a civil survey of the sewer and subway will be required to ensure it is capable of taking the additional load of the inserted pipe and any required fire-proofing annulus fill.
Operating Windows	If an engineering solution were to be found for subways, there are delivery constraints on the Victoria Embankment as there are limited operating windows, of four months per annum, for working on the network. This is driven by 1 in 20 peak demand requirements at the Victoria Embankment district governor. During work on the assets along the Victoria Embankment, flow is restricted to this governor, so work cannot take place in peak demand periods.
Access	The Victoria Embankment is a TFL strategic route (the A3211) and delivery of insertion along this route would require traffic management on the road for an extended period whereas the Monck Street to Farringdon Street route involves traffic management that will move locations as work progresses. In addition to the Monck Street to New Bridge Street going via the Victoria Embankment, the route would require closure of the Blackfriars underpass as the mains cross the river Thames here in the roadway. TFL are unlikely to allow a road closure of such a major arterial route to allow this work to be carried out.
Thames Tideway	The Thames Tideway Tunnel is an under-construction, 25 km tunnel running mostly under the River Thames through central London. Their Victoria Embankment site is opposite the London Eye.  *Figure 7: Thames Tideway on the Victoria Embankment* As the Thames Tideway site on the Victoria Embankment is already encroaching into the carriageway, access to the Victoria embankment is restricted while work on the Thames Tideway is ongoing.

Scheme feature	Description
	The Thames Tideway project is due for completion in 2023.
Resilience	This route has a more major impact on customers in the event of a pipe failure in the future, and is therefore a less-resilient solution.

Route Used	Average Scenario	Peak Day Scenario
Monck Street to New Bridge Street	10,500	26,000

Table 16: Customers Impacted in Event of a Failure

Table 17: Section 10: Option 2: Discussion

The costs for this option are summarised below (note the costs include the abandonment of the Monck Street to Farringdon Street section):

Item	Option 2 Monck St to Farringdon St
Engineering Design	
Project management	
Materials	
Main Works Contractor	Redacted due to commercial sensitivity
Specialist Services	
Vendor Package costs	
Direct Company Costs	
Indirect Company Costs	
Contingency	
Total Installed Cost	
Cost Estimate Accuracy	

Table 18: Section 10: Cost estimate

Section 10: Option Technical Summary

Based on the above option summary and discussion, the following table summarises the key features, pro's and con's of each option.

	Option 1	Option 2
Scheme Title	Monck Street to Farringdon Road	Monck Street to New Bridge Street
Pro's	More resilient long-term solution with fewer customers impact in the event of future pipeline failure (250 to 11,000 customers impacted) 100% operating window for outages on network to facilitate construction.	
Con's	Complex access via congested major central route through the heart of the city, passing major landmarks and the Theatre District. Major stakeholder engagement will be required to limit the impact of the work. Some construction within subways, but less than Option 2.	Less resilient long-term solution with between 10,000 & 26,000 customer impact in the event of failure. Complex access along Victoria embankment; Victoria embankment is also impacted by the ongoing Thames Tideway project until 2023. Limited operating window; 4 months per year due to limitations on Victoria embankment district governor. Replacement of 2.3km of gas-pipe in congested Victoria embankment services subway.
Total Installed Cost	Redacted due to commercial sensitivity	
Cost Confidence		

Table 19: Section 10: Option Technical Summary

Section 10: Option Cost Summary

A forecast breakdown of the percentage of total installed cost estimate for the options is presented in the table below.

Item	Option 1 Monck St to Farringdon St	Option 2 Monck St to New Bridge St
Engineering Design		
Project management		
Materials		
Main Works Contractor	Redacted due to commercial sensitivity	
Specialist Services		
Vendor Package costs		
Direct Company Costs		
Indirect Company Costs		
Contingency		
Total Installed Cost		
Cost Estimate Accuracy		

Table 20: Cost Summary of Options for Section 10 of LMP

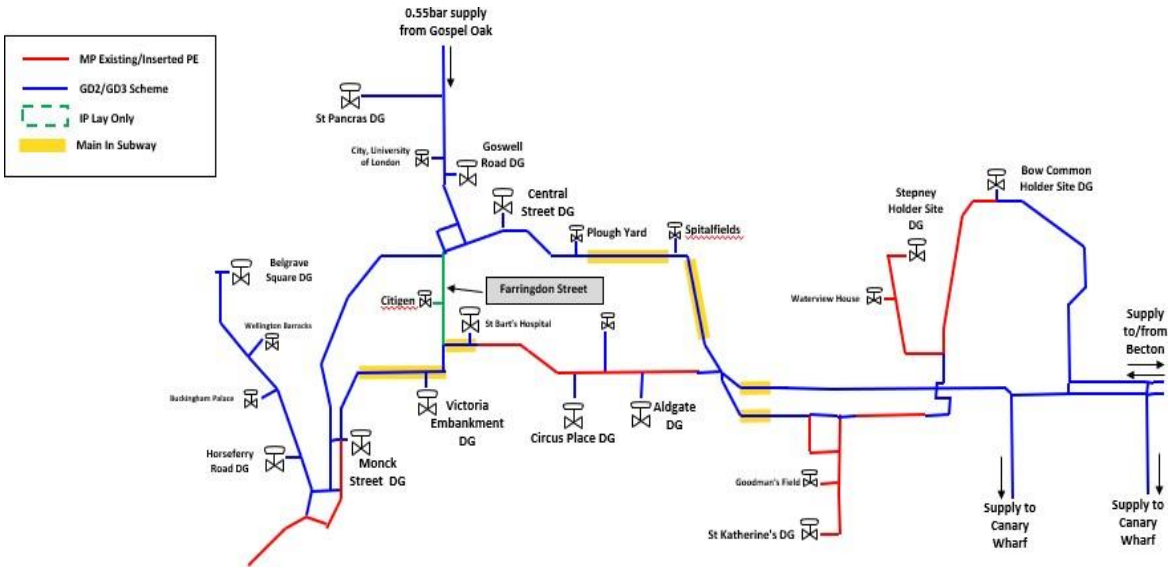
Conclusions

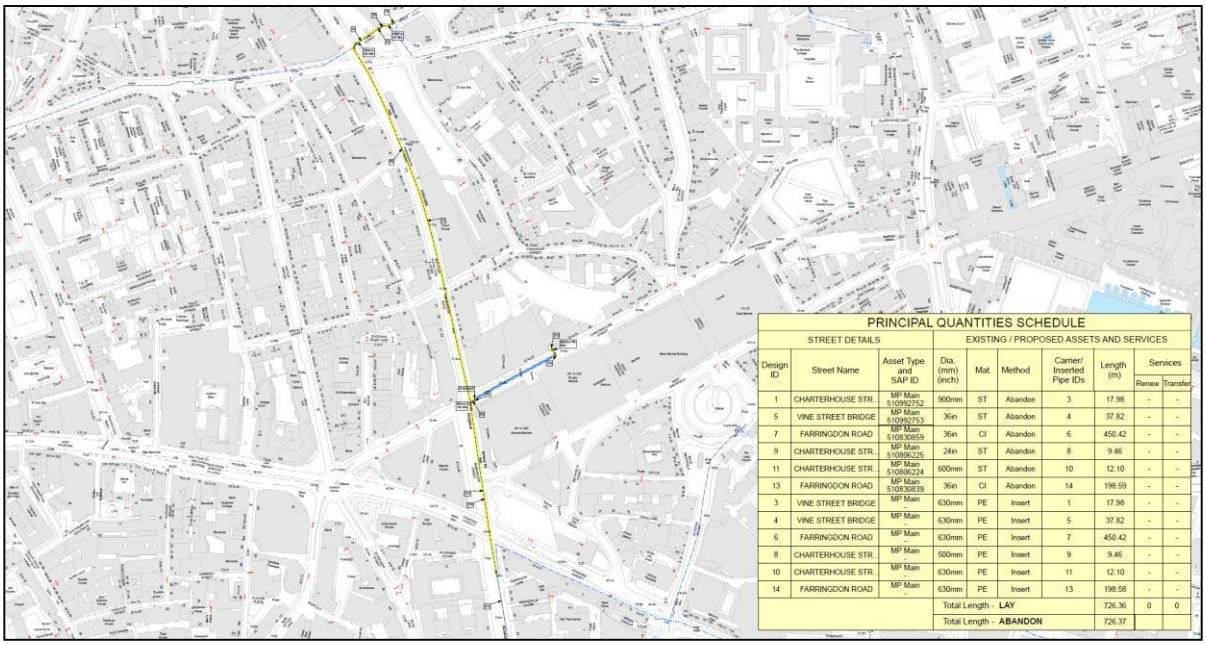
Option 1 (Section 10) is our preferred option to renew, with abandonment for section 11. Based on the options assessment discussed above Option 1, is not only the lowest cost, but it also provides a more resilient long-term solution, with fewer risks associated with construction in the Victoria Embankment area (and interfacing with the Thames Tideway project) and gas network outages are possible at any time of year, to facilitate construction.

For Option 1, although we are looking to abandon Victoria Embankment district governor, along with the associated MP mains in the Subway, additional resilience will be brought to the network by installing a replacement, on a new site at Blackfriars Court and installing a completely new district governor at Bloomsbury Square Gardens, to the north west of the network. The result of this is that pressures will be significantly improved within the LP system under normal operation and, should we experience unplanned failure of either site, then the customer impact would be less significant, ensuring that we are maintaining a keen focus on security of supply across our network.

Section 12: Farringdon Street

This section is comprised of 1 km.





PRINCIPAL QUANTITIES SCHEDULE

STREET DETAILS			EXISTING / PROPOSED ASSETS AND SERVICES					
Design ID	Street Name	Asset Type and SAP ID	Dia. (mm) (inch)	Mat.	Method	Carrier/ Inserted Pipe IDs	Length (m)	Services
								Renew / Transfer
1	CHARTERHOUSE STR.	MP Main 5109927S2	900mm	ST	Abandon	3	17.98	- / -
5	VINE STREET BRIDGE	MP Main 5109927S3	36in	ST	Abandon	4	37.82	- / -
7	FARRINGDON ROAD	MP Main 510830859	36in	CI	Abandon	6	450.42	- / -
9	CHARTERHOUSE STR.	MP Main 510806225	24in	ST	Abandon	8	9.46	- / -
11	CHARTERHOUSE STR.	MP Main 510806204	600mm	ST	Abandon	10	12.10	- / -
13	FARRINGDON ROAD	MP Main 510830839	36in	CI	Abandon	14	198.59	- / -
3	VINE STREET BRIDGE	MP Main -	630mm	PE	Insert	1	17.98	- / -
4	VINE STREET BRIDGE	MP Main -	630mm	PE	Insert	5	37.82	- / -
6	FARRINGDON ROAD	MP Main -	630mm	PE	Insert	7	450.42	- / -
8	CHARTERHOUSE STR.	MP Main -	500mm	PE	Insert	9	9.46	- / -
10	CHARTERHOUSE STR.	MP Main -	630mm	PE	Insert	11	12.10	- / -
14	FARRINGDON ROAD	MP Main -	630mm	PE	Insert	13	198.58	- / -
			Total Length - **LAY**				726.36	0 / 0
			Total Length - **ABANDON**				726.37	

Farringdon replacement assumes the majority of isolations can be undertaken using the valves already present.

Again, there is an element of steel we believe will require undertaking and this has been considered as well as an allowance of 30m to accommodate the lift and lay of the steel.

As with Trafalgar, the location of the works has meant traffic management considerations have doubled. Said location will also have an impact upon the likely number of VMS boards required.

Appendix 3. Key challenges: LMP overall Scheme

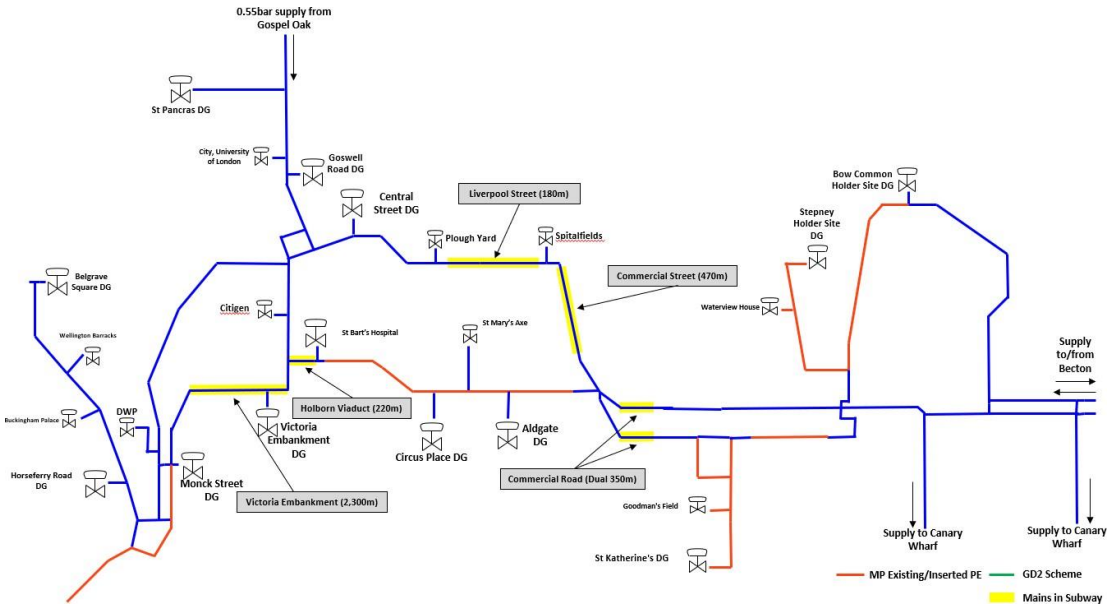
In addition to the significant challenges that one would expect while carrying out complex works in the centre of London; some specific engineering challenges need to be overcome in order to complete the project. The most significant of these are:

- **Subways**: The existing assets are located in subways at five locations. The longest of these is the Victoria Embankment at 2.3km.
- **Governors**: As the project will elevate the network to 2bar, a number of Medium Pressure – Low Pressure district governors will be replaced since the existing regulators are only rated to 1bar and also induce obsolete equipment.
- **Crossings**: The assets cross; rail, river, canal or underground routes at four locations

We have considered options in response to these challenges:

Subways

The existing asset is located in a utility subway at five locations along the route of the LMP project.



The longest subway in the remaining scope of works is the Victoria Embankment utility subway which is 2.3km long.

There are a number of challenges associated with subways which will be explored further below:

- **Access:** there is generally limited access into the subways
- **Engineering solution:** Assets within subways are required to be made from a fireproof material or have a fire protection system.
- **Subways Act:** The Subways Act 1893 requires us to use subways where they exist

Access: Getting access to our assets in a subway is challenging as it is through small openings. Generally, our assets are at the bottom of the subways with more recently installed power cables and fibre-optic telecoms above them restricting access.

Additionally, some of the subways are listed heritage structures which require the agreement of statutory bodies such as EA or Heritage England before work can commence.

Engineering Solution: Assets within subways are required to be made from a fire-proof material such as steel or require fire proofing/defence; this may include the filling of the annulus with a fire-proof material such as grout.

In addition to the actual renewal technique, there are challenges associated with the temporary works that would be required to carry out the work on the assets in the subway.

Subways Act: The Subways Act 1893 requires the business to use the utility subways in London, where they exist. It is only possible to open cut alongside the subways where there is sufficient business justification to do so, and this is agreed with the Local Authority.

Governors

Pressure reduction stations will need upgrading or new pressure reduction stations will need installing at 13 locations along the route of the LMP project.

A number of challenges associated with governors will be explored below:

Purchase of land for new Governors: There is a lack of land available for new governor installation. The majority of governors sites will be replaced in situ using the footprint of the existing governor.

Crossings

There are 4 locations along the route of the LMP project where there are special crossings that cross either rail, underground, canal or river.

Challenges associated with specific crossings:

Victoria Embankment to New Bridge Street: this section requires crossing of the London underground (district/circle line). The roof of the London underground line is only 0.3meters beneath the road surface on the Victoria Embankment, thus a tunnel crossing beneath the railway line would be required to allow for a new MP to crossing.

Thames River crossings at Twelvetrees Crescent: Currently there is a twin 48” MP above crossing. This work will require one of the mains to be upgraded to IP. The mains are bolted to the side of the bridge crossing the Thames river beneath (approximately 20 to 30 meters below the bridge).

Appendix 4. Example of Recent Mains Failure in London – Consequence of Failure

The impact of failure of the LMP network has significant consequences. This is affected by the location, depth and complexity of repairs on these assets. Due to the dense urban nature of the centre of London, the impact on customers and the public is large and results in significant displacement of people for long periods of time.

The case study below is a failure on our MP asset on Horseferry Road. This failure is typical for a failure on the LMP network.

What happened: In the winter of 2018 a two-meter longitudinal split on the bottom of the 36" CI MP pipeline resulted in significant gas readings over a radius of 30 metres.

Impact on customers: 200 people were immediately evacuated from the area (cordon 50m) while the area was made safe by venting, finding and fixing the asset over a period of four days. This impacted small and large businesses (shops, cafes and offices) and residential areas (flats and houses). Customers, therefore, could not access their properties and were found alternative accommodation for the period.

To access our asset, we reduced pressure on 2km of our Central London MP network, thus decreasing the inbuilt resilience during peak-profile periods. Under periods of higher load, this could have resulted in pressure issues to several tens of thousands of London's residents.

Safety: Significant, widespread and uncontrolled escape in an area of central London which effectively brought the area to a complete standstill. Gas readings could be detected over a wide 30m radius both internally and externally to the domestic, non-domestic MOBs/Non-Mob properties located in the vicinity of the escape.

Very deep excavations were dug at short notice to find and fix the leaking asset; the fix was difficult to implement due to the engineering complexities and constraints presented by the site.

Cost to business: In total this single repair, considering plant, tools, equipment, labour, reinstatement and repair, cost Cadent *XXXX*. No GSOP payments were made. For those customers in alternative accommodation, incidental expenses to cover food and other expenses were paid.

Appendix 5. CBA Basis of calculation

As discussed in Section 6, the optioneering for the LMP project was completed in RIIO-1. This concluded that a proactive renewal programme around the inner-city using pipe insertion was the optimum solution to deliver best value to customers.

We have updated and reviewed our CBA analysis with the latest costs and benefits to validate that this proactive programme of work is still cost beneficial over the baseline case.

We have considered the following programme options:

- **Baseline**: Reactively repair following failure (Once the RIIO-1 investment is complete)
- **Option 1**: Proactive renew prior to failure (RIIO-2 & 3 investment)
- **Option 2**: Proactive option with investment in RIIO-2 only (RIIO-2 costs of option 1)

CBA Approach

We have used a full cost benefit analysis of the whole RIIO-2 programme to ensure overall value for money. Our approach is compliant with HM Treasury's Green Book and the relevant Ofgem guidance. We have followed the Ofgem approach, spreadsheet and calculations. We have adjusted some of the societal benefit values to better represent the unique environment in the LMP zone.

The table below sets out the options taken into the CBA modelling, together with the costs and benefits modelled. Because of the importance of the cost benefit case on the safety assumptions, we have included an option to test the sensitivity of the preferred option results to the safety assumptions.

Programme Option	CBA Option	Modelled Costs	Modelled Benefits
Baseline: Reactive repair upon failure	Baseline	Repair costs of reacting to failures from modelling	Private and social costs due to failures associated with the option: • Leakage • Traffic disruption • Property damage • Fatalities • Non-fatal injuries
Option 1: Preferred option Investment for RIIO-2 & 3	Option 1: Continued proactive replacement of entire LMP scheme	RIIO-2 & RIIO-3 costs as submitted Repair costs of reacting to failures from modelling	Private and social costs due to failures associated with the option: • Leakage • Traffic disruption • Property damage • Fatalities • Non-fatal injuries
Option 2: Preferred option with continued investment in RIIO-2 only	Option 2: Continued proactive replacement through RIIO-2	RIIO-2 costs as submitted Repair costs of reacting to failures from modelling	Private and social costs due to failures associated with the option: • Leakage • Traffic disruption • Property damage • Fatalities • Non-fatal injuries

Table 21: Basis of calculations in the CBA template

Benefit Calculations

The detailed calculations of the benefits included in the Ofgem templates are set out below.

Background to our Modelling Approach: In RIIO-1 we have invested in the software tool, AIM, to allow us to build asset management capability using the NOMs approach. AIM has been used to support the construction of the RIIO-2 plan. The software includes an optimisation capability which allows us to model different investment scenarios, produce optimised plans and test their cost benefit. The CBA capability enables us to find the solution to a problem with many restrictions and millions of potential solutions (options).

AIM has been used to model all mains assets. This has involved forecasting how the asset base will perform into the future in terms of asset failures, the impacts on consumers and the environment, and the financial impact. Our model has been applied in at pipe level (i.e. individual assets and their performance have been modelled, producing precise results for the plan).

The AIM model calculates failures rates, the repair costs associated with pipeline failures, leakage both general and due to failure, and explosions and their consequences. The model forecasts the growth in failures through time and calculates the growth in consequence as a result of this.

For LMP the forecast failure rate and leakage was taken from AIM for all pipes before and after replacement. However, the cost to repair, and the safety consequences were sufficiently different to the rest of our pipe network that a more accurate representation could be achieved by computation outside AIM.

Overall the benefits calculated for the CBA were:

- Cost to repair the pipe after a failure
- Leakage of gas from the pipelines and joints
- Property damage resulting from gas seepage into basements causing an explosion in a nearby building
- Fatalities within and outside of a building with the explosion
- Non-fatal injuries within and outside of a building with the explosion
- Traffic disruption due to repair activities

The model uses the asset information and proactive and repair costs particular to the LMP Zone. We also added traffic disruption as used in the LTS pipelines CBA modelling as the London MP pipe failures have resulted in similar disruption to what would be expected from an LTS pipeline failure. The leakage rates have been calculated in the same way as we have modelled other mains within the North London network.

The probability of an explosion is calculated in this model is the un-normalized MRPS (using the latest indicative MRPS results) risk score of the pipe which represents the expected number of explosions each year. This probability is then increased through time at the same rate as the number of failures. We then multiplied this probability by the consequence in terms of property damage, fatalities, and non-fatal injuries to get the safety risks, to account for the special environment in the London zone.

The potential consequences of failure considered for the LMP project have been expressed as monetary values as per the agreed NARMs industry methodology, as shown below.

Customer Driver	Data source
Environment – GHG emissions (unit)	UK Government: Value agreed with Ofgem
Safety – injuries and deaths (unit)	UK Government (HSE): Value agreed with Ofgem
Leakage – commercial value of lost gas (unit)	Shippers: Value agreed with Ofgem
Financial impact – cost of repairs (unit)	Company accounts
Financial impact – cost of replacement (unit)	Company accounts
Traffic disruption	Department for Transport
Property damage	From sales data and other references

Table 22: Sources of societal benefits

These values have been estimated using a range of sources, which have been built into the model, as well as published government values for carbon, risk of fatality, and non-fatal injuries.

Application to the LMP

The London Medium Pressure Zone is unique. The area has a very high-density of significant buildings with gas mains running within close proximity. Many of the buildings are heritage sites, and several are of national and international importance, including: palaces, embassies and key government departments. Examples of these buildings are the Houses of Parliament, Somerset House, the Adelphi theatre and Charing Cross Station. The consequences of damage to these buildings is unquantifiable and would impact tourism, national reputation and national interests. The consequences can be likened to the fire in Notre Dame Cathedral in Paris in 2019.

There are also a very high-density of office buildings, again with many of these being critical to managing the nation and our national interests. The zone is a major tourist location with shops, restaurants, theatres, museums, art galleries etc. As such, the zone is constantly busy with pedestrians, traffic, commuters and numerous buses, taxis and underground and rail stations. The number of people in the area is constantly at the high end of the spectrum when compared to other city locations across the UK.

The consequences of any potential gas explosion within the zone, are radically different to any other, similarly sized, area of the UK. We have identified consequences that are different to what has been assumed in the AIM model, and need, post-processing, and adjustment to more accurately represent the risk in the zone. These are:

- Property damage due to higher than the UK average property values, and a significantly higher level of larger, more prestigious and nationally important properties than the rest of the UK
- Fatalities and injuries due to the higher than average number of people within close proximity to the explosion including those in the properties and the higher than average number of pedestrians and commuters near the buildings
- Traffic disruption from failures due to significant work to isolate and repair

We assume that as per the NOMs methodology 20% of the building's occupants are killed in an explosion with seven people injured for every death. However, we use occupation values to match the higher density around London MP pipes rather than the standard 2.3 people per property (average domestic) used in NOMs. The density estimates are adjusted according to property usage, typical occupation densities and percentage of the day when highly occupied. The results are shown in Table 17.

Property damage is applied differently from NOMs as the buildings are largely multi-storey. The assumption is made that any explosion would destroy the first three floors of the building forcing the rebuilding of all properties on those floors.

Additional items not quantified

There are a number of additional items which we have not included in the CBA, if included they would increase the NPV for intervention.

We have not considered the impact of higher than average property price increases over time, as this is too uncertain to forecast. London house price rises have on average outstripped inflation, and as such it would be reasonable to inflate their value through time.

We are also aware that many of the building contain articles of extremely high value and of historical importance, i.e. art galleries and museums. Some of these are irreplaceable. We have not tried to quantify the value of these elements in the modelling.

Any gas explosion would cause significant disruption to the locality affected. Businesses, workers, tourists and commuters would all be impacted for several days or weeks during the clean-up and reconstruction and repairs. These consequences have not been quantified and therefore have not been included in the cost benefit analysis.

Property Assessment Modelling

The LMP programme was started in RIIO-1 and we undertook geospatial modelling to better understand the unique characteristics and consequences of the zone. At this time, we did an assessment of the value of the properties close to the gas mains by taking periodic transects along the route and classifying and valuing buildings and treating these as the average for the section analysed. For RIIO-2 we have undertaken a similar assessment and identified the properties close to the relevant pipelines and their associated floor areas. We have determined the number of floors by assessing each building using mapping software and the category of building, e.g. offices, residential, embassies etc. through the use of the addresses contained within the buildings.

We have then used a variety of different sources, e.g. Zoopla, government data etc. to determine the average property values and scaled this based on the property floor area.

The occupation densities for different property categories have been calculated using the average people that would occupy the floor area considering the operating hours for the building type (i.e. offices are occupied for 10 hours a day, 5 days a week).

From these we have calculated the weighted averages for the property values and the occupation levels for each pipeline section. The values used for the analysis are presented in the table below.

Section	Property Value (m)	Occupation Density (no. people / building)
RIIO-2 weighted average		313
1. Belgrave Square to Monck Street		229
2. Salmon Lane Bridge to Commercial Road		26
3. Commercial Road to Farringdon Street		110
4. Commercial Street to Plough Yard		77
5. Farringdon Street to Plough Yard		226
6. Goswell Road Abandonment		145
7. Commercial Road Abandonment		72
8. Bromley by Bow to Bow Common HS		94
9. Bow Common to East India Dock Road		40
10. Monck Street to Farringdon Road (Via Trafalgar Square)		311

Section	Property Value (m)	Occupation Density (no. people / building)
11. Monck Street to New Bridge Street (Abandonment)		582
12. Farringdon Street		328

Table 23: Modelled property damage and occupation values

In the analysis, we have assumed that the explosion would only impact on a maximum of three floors and hence fatalities and property damage are only for the first three floors of the building.

Cost Benefit Analysis Results

The results of the London Medium Pressure cost benefit analysis are set out in the table below.

Option No.	Option Name	NPV Relative to Baseline	Cost beneficial	Payback Year	RIIO-2 Spend	Ratio NPV to RIIO-2 spend
Baseline	Baseline					
1	Continued Proactive Programme (RIIO-2 and 3)	Redacted due to commercial sensitivity				
2	Continued Proactive Programme (RIIO-2 only)					

Table 24: Results of cost benefit analysis for LMP (£m)

Option 1 is our preferred option to deliver the entire scheme throughout RIIO-2 and RIIO-3. The table below shows the drivers underlying these positive results in more detail:

Option No.	Option Name	PV Expenditure & Costs	PV Environment	PV Safety	PV Other	Total NPV	NPV Relative to Baseline
Baseline	Baseline						
1	Continued Proactive Programme (RIIO-2 and 3)		Redacted due to commercial sensitivity				
2	Continued Proactive Programme (RIIO-2 only)						

Table 25: Breakdown of the results of the cost benefit analysis for LMP (£m)

The full cost benefit of the proposed programme for RIIO-2 and RIIO-3, including all three types of benefit is set out in Option 1. The positive NPV result is being driven mainly by the safety benefit, which has a net PV of *XXXX* over the baseline scenario. Option 2 shows a similar cost benefit, for the RIIO-2 investment only, again, the positive NPV is mainly driven by safety with a net PV of *XXXX*. **Options 1 and 2 are both cost beneficial and demonstrate that continued investment in the LMP programme is cost beneficial and in line with customer and stakeholder expectations.**

Because of the size and importance of certain properties and the general high-level of people in the zone, the safety concerns are real and significant. This supports the company's decision that the safety risks are unacceptable and must be addressed through a continued proactive programme of work. **The programme for LMP is cost beneficial and must go ahead for safety reasons.**

Appendix 6. Customer Engagmenet

Costumers: Through our Business Options Testing (BOT) we engaged with customers in London on the medium pressure project. We presented the material shown here and described the proposed investment work.

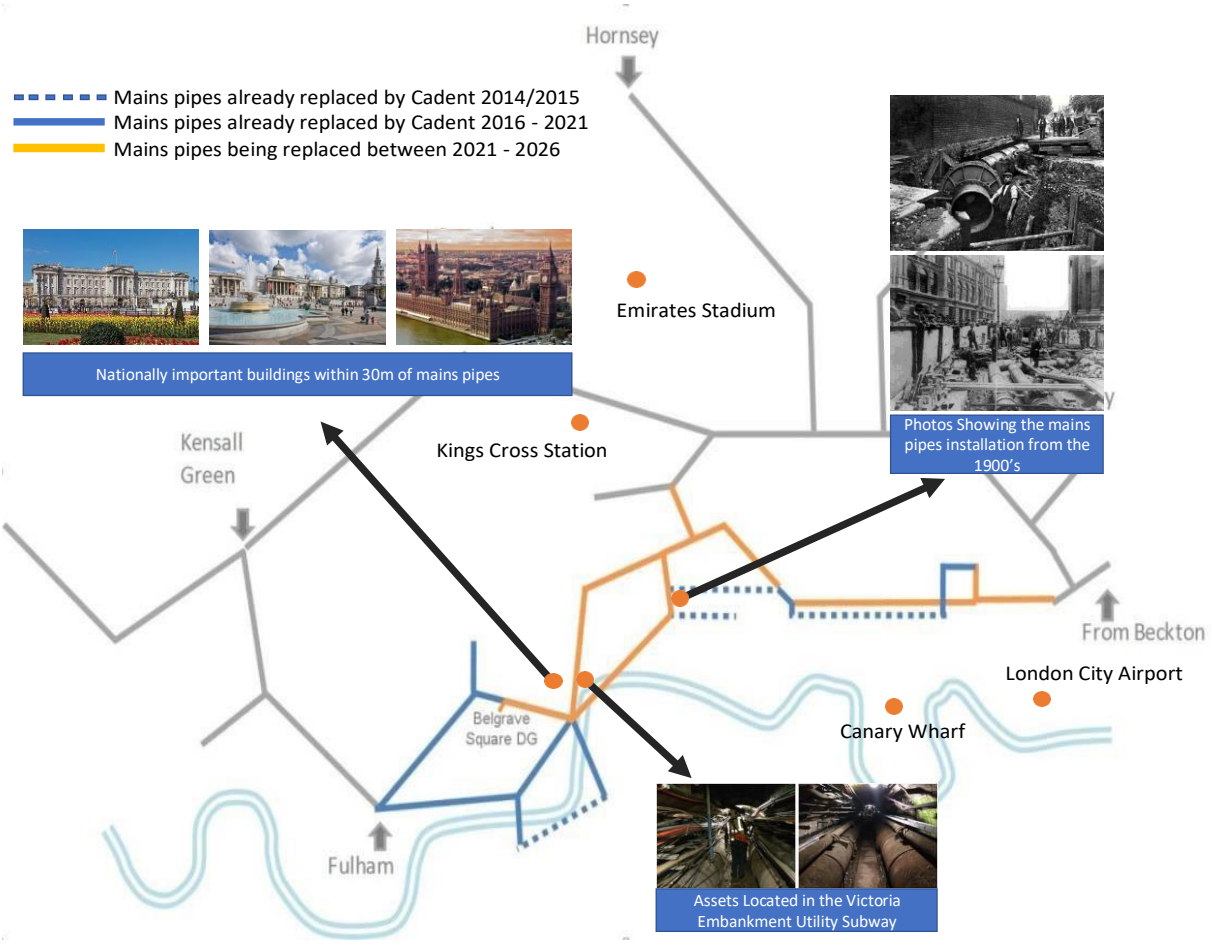


Figure 8: LMP Route Schematic

What you can see in the figure above is a schematic of the LMP assets Cadent need to replace in the next 5-10 years in central London. Blue means Cadent have already replaced metal pipes with plastic pipes. Orange mean Cadent still need to replace these pipes. As you can see (and in more detail in Appendix 2) some of the pipes are running only meters from nationally significant buildings. Additionally, these works will cause disruption of traffic such as closed off roads, which might impact people's commute.

Customer were keen to be kept informed about our plans and how it might influence travel (commuting) in the centre of London. They stated that closures are usual around London, and as such they don't see an issue, preference was not to do it over the summer months as these are all highly touristic areas and they become even busier over the summer months, closures in this period in the central zone might cause more issues. Cadent should make sure that buildings of national significance get priority as it would be tragic to damage them, also, areas of high footfall/high density should be kept safe. How many people affected should be a guiding principle for targeting work.

Customers also asked that if major road works are going on in London, Cadent should piggyback on the job to do pipe replacement, more coordinated multi-utility working was welcomed. As a response we will work with stakeholders to co-ordinate our interventions in the capital (see next section).

Stakeholders: Due to the detail required for successful engagement at each location in London, during RIIO-1 bespoke engagement and communications plans have been crafted to best suit the needs of for each work programme, its location, profile and stakeholders (local authority, elected representatives, local businesses). As overview of some of the works and engagement is below;

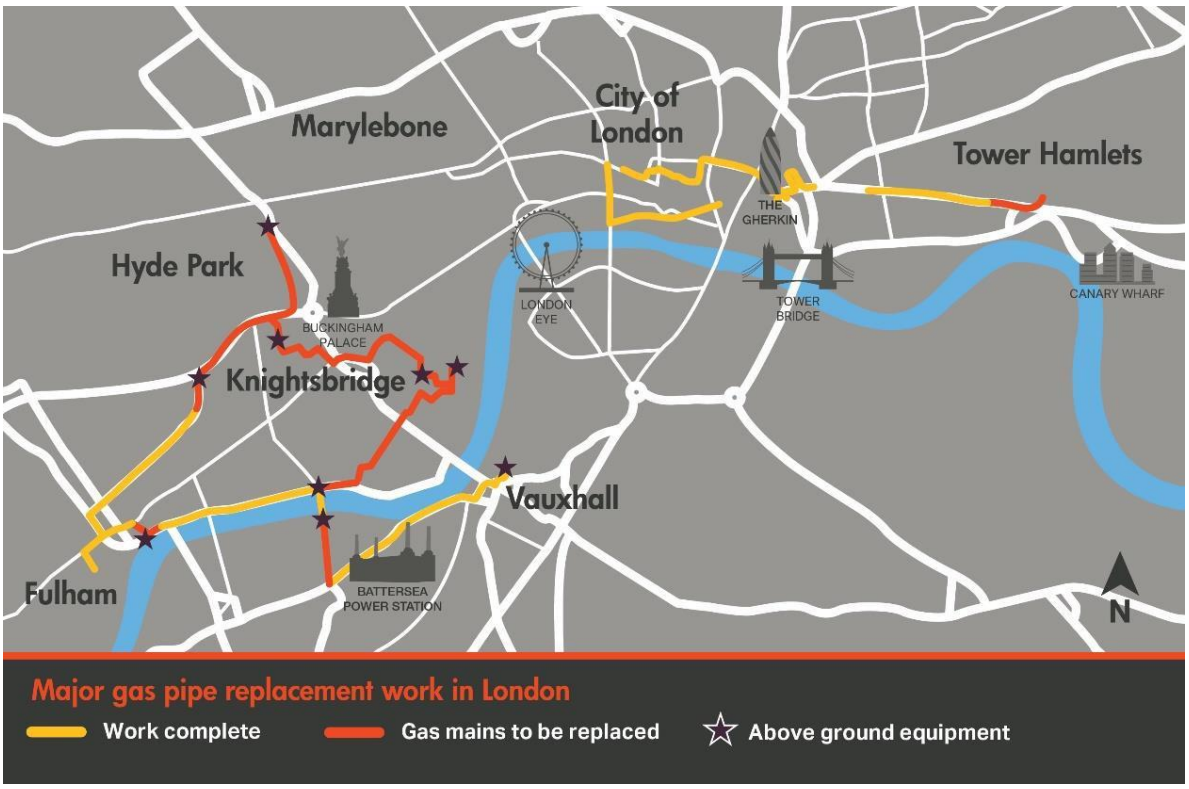


Figure 9: Location Map

Stakeholder type	Name	Engagement detail
London Boroughs	Tower Hamlets	GD1 works full local authority and public engagement
	Kensington & Chelsea	GD1 works full local authority, local business and public engagement programme
	Newham	GD1 works full local authority, local business and public engagement programme
	City of London	GD1 works full local authority, local business and public engagement programme
	Camden	GD1 works full local authority, local business and public engagement programme
	Islington	GD1 works full local authority, local business and public engagement programme
	Hackney	GD1 works full local authority, local business and public engagement programme
	Westminster	GD1 + GD2 commenced

Stakeholder type	Name	Engagement detail
Transport for London	TfL	Works often conducted on TfL land, however they are also responsible for granting permits and we engage with them to ensure that disruption to public transport is minimal and where unavoidable, that alternative transport provisions are put in place.
Royal Parks	Royal Parks	To build a relationship with the stakeholders so that they understand what we are doing and why. Coordination of work between Local Authority and TfL to ensure that we are not disrupting any major events (Winter Wonderland, Hyde Park Summertime festival, etc)
Met Police		To gain support for undertaking disruptive works in high profile locations
GLA		To aid understanding of the scope of works we undertake and why. We sit on the GLA High Level Infrastructure Board (James Harrison) and working group (Emily Wilson-Gavin). We feed details of our work programmes into collaborative infrastructure and utility partner tools (such as the IMA and LUAR)

Figure 10: Summary of Engagement

In 2019 we commenced a programme of engagement with London Boroughs to join the dots between the RIIO-1 work currently being conducted and the works that we are proposing to carry out in RIIO-2.

The feedback from the most recent feedback with Westminster City Council was that as we move from RIIO-11 into the RIIO-2 price control period, they ‘want to engage frequently and meaningfully in ways such as this meeting (14/8/19) to discuss lessons learned from previous works, understand better our current priorities and what we are currently doing, as well having an open dialogue about what we are planning to do in the future.’