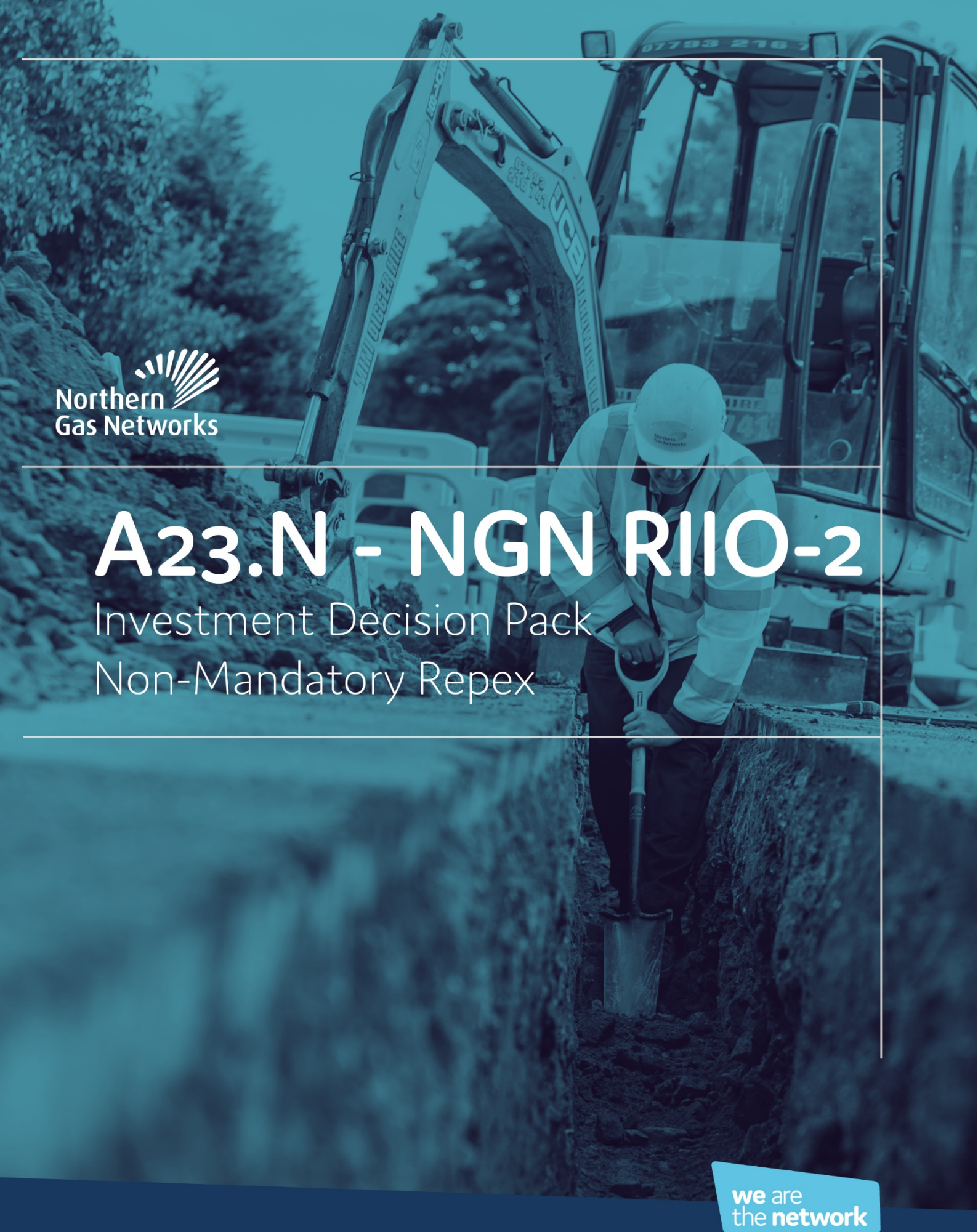


Northern Gas Networks

A23.N - NGN RIIO-2

Investment Decision Pack
Non-Mandatory Repex

we are the network

1. Table of Contents

2. Introduction

This Engineering Justification paper outlines the process we have undertaken to determine the Non-Mandatory REPEX investments we plan to complete during RIIO-2. Non-mandatory repex investments are made to address known or forecast issues with distribution pipeline and associated assets which are not covered by specific HSE intervention requirements. The decisions to make these investments are made based on the balance of the cost of making the investment, the benefits that it will deliver in the future and the negative consequences of not making these investments, covering the following discrete Investment areas;

- Tier 2B Iron Pipes, those >8"and <18" diameter that are below the Tier2A threshold. (Further Tier 2A details outlined in Mandatory Paper)
- Tier 3 Iron Pipes, which are =>18" in diameter
- Steel Pipes >2" in Diameter
- Zero Scoring Pipes, Iron Pipes that are over 30m from a property
- PE pipes
- Overcrossings (any of the categories above where the pipe is exposed and crossing, for example, road, watercourse, railway or land not controlled by NGN)
- Diversions
- Risers supplying multi-occupancy buildings

The basket of work detailed within this Engineering Justification paper has been developed systematically through our asset management decision-making process during which we analyse risk and value and trade-off between different intervention and management options. This process includes the following steps which are outlined in more detail later in this paper:

- An understanding of the types of assets we own and the day to day operational issues we encounter
- Knowledge of what our customers and stakeholders want and the outcomes that best achieve this
- Establishing the drivers for investment and the asset intervention options
- Generating the probability of failure data for our assets using the Network Asset Risk Metrics (NARMs) methodology as a basis for these calculations
- Agreeing a set of values to use in our Value Framework through which we can assess the intervention options objectively, holistically and consistently
- Undertaking asset class optimisations within our Asset Investment Planning system, C55, to maximise the value from our investments
- Comparison of the net present value of each intervention option using a consistent Cost Benefit Analysis tool
- Making an informed decision on the optimal workload and expenditure forecasts for our RIIO-2 Non-Mandatory REPEX programme that is in the best interest of both our existing and future customers
- Ensuring we still meet the obligations of our Safety Case regarding buried Assets

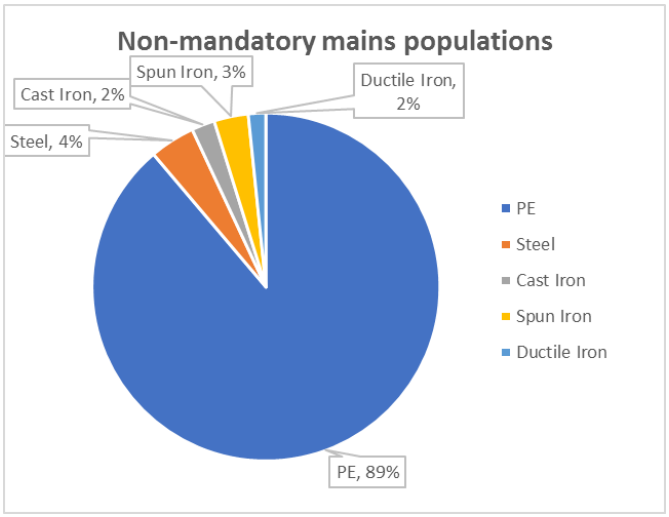
3. Equipment Summary

NGN's pipe distribution network < 7 bar consists of approximately 35,000km of mains and over 2.5 million services providing gas to domestic, commercial and industrial consumers. This network, whose development began in the late 1800's and continues to this day, is constructed from a variety of materials, principally pit-cast iron; spun-cast iron; ductile iron; steel and polyethylene.

There is a total of approximately 6,000km of Tier 1 iron mains (<= 8" diameter within 30m of property), Tier 2A iron mains (>8" and <18" diameter scoring above the Risk Action Threshold) and steel mains <= 2" diameter. These are considered as Mandatory and their management and replacement is covered elsewhere.

The current populations and material mix for non-mandatory distribution mains are shown below:

	km	%
PE	25,572.2	88.7%
> 2" Steel	1,226.1	4.3%
Cast Iron	625.1	2.2%
Spun Iron	922.7	3.2%
Ductile Iron	473.8	1.6%
TOTAL	28,819.9	100.00%



4. Problem Statement

When the gas distribution network was established, the pipes transporting gas around towns and districts were made from iron. Iron was considered to be a sound material for gas distribution at the time. However, following several high-profile fatal incidents, national risk-based mains replacement programmes to replace iron mains came into operation and have been in place in various forms since the 1970s.

The Iron Mains Replacement Programme (IMRP) was introduced by the Health & Safety Executive (HSE) in 2002 specifically to address concern about the failure of iron mains, particularly cast-iron mains due to fracture. The Mains Risk Prioritisation System (MRPS) was also created at this time to provide an estimate of the risk of an incident presented by each individual section of main. This enabled NGN and other gas distribution networks to prioritise investment on iron main replacement, targeting investment towards replacing the riskiest pipes. The IMRP required the distribution companies to replace all 'at risk' iron mains (i.e. those within 30 metres of a property) within 30 years of 2002 and became known as the "30/30 programme".

Following a 10-year review commissioned by the HSE, IMRP was revised in 2013 to become the current Iron Mains Risk Reduction Programme (IMRRP), also known as 'The Three-Tier Approach'. The key changes to the methodology were:

- For most iron pipes (those ≤ 8" diameter – Tier 1) the requirement remained unchanged – those pipes within 30m of property are still required to be decommissioned by 31st March 2032.
- For iron pipes >8" and <18" (Tier 2) a Risk Action Threshold was established with all pipes above this required to be decommissioned.
- Tier 2 pipes below the Risk Action Threshold and Tier 3 pipes (iron pipes ≥ 18") are subject to Condition Monitoring and management regimes (which may include decommissioning where the pipes have deteriorated beyond safe or effective repair) and may also be subject to decommissioning where this is justified by a Cost Benefit Analysis providing;
    - A greater focus on risk management;
    - A greater flexibility to prioritise replacement based on a wide range of customer and stakeholder benefits, including reductions in gas losses, operating costs, and improvements in safety risk;
    - Greater flexibility to consider other remediation techniques (where available and accepted) to continue the use or extend the life of larger diameter mains; and
    - Replacement due to condition or risk is required to undergo cost benefit assessment

This more flexible approach allows us to better balance the removal of the highest risk pipes with delivering efficient, effective and safe management of the network and value for money for customers.

Tier 2B and Tier 3. The main driver for the workload is to provide value for money for the customer, which is assessed using our cost benefit analysis and Value Framework model based on historic and forecast asset performance, with the impact on monetised risk being measured using the NARM methodology. A proportion of work will also be built into Tier 1 projects to deliver overall efficiency.

RIIO-2 Tier 2B and Tier 3 workloads have been forecast by analysing the remaining pipe population that passes cost benefit analysis with a discounted payback period of 20 years or less.

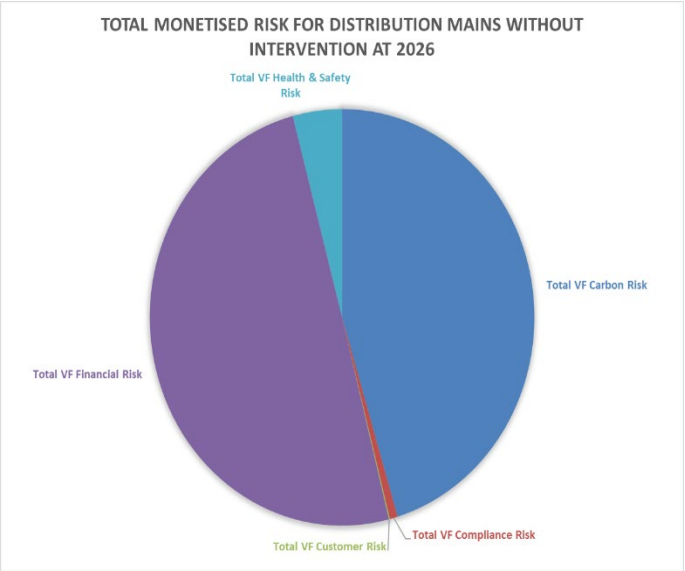
Steel (>2") Working the other GDNs and an external expert organisation we have identified that steel mains are deteriorating at an increased rate. From our own internal analysis, we have identified that there is an increasing level of these steel mains failures resulting in gas entering properties. The combination of these factors show that it is beneficial to increase our rate of replacement in GD2. This increase provides additional value for customers and achieves a discounted payback period of 20 years or less.

Zero Scoring Mains. There are three main drivers for replacing these pipes:
- **Security of supply issues.** We have several aging single-leg mains where security of supply issues have been identified. We plan to replace a proportion of these pipes in RIIO-2 on a risk basis.
- **Efficiency and delivering best value for our customers**. This can be driven by two factors. We add zero-scoring mains into mandatory replacement projects for efficiency where we expect the pipes to because scoring pipes in the future. We also carry out work using CBA analysis for "stand-alone" zero-scoring projects taking into account poor condition and customer impact.
- **Environment**. Failure of these assets result in fugitive emissions of gas (leakage) with a significant environmental impact. Asset replacement results in the removal of these emissions and significant improvement in environmental performance.

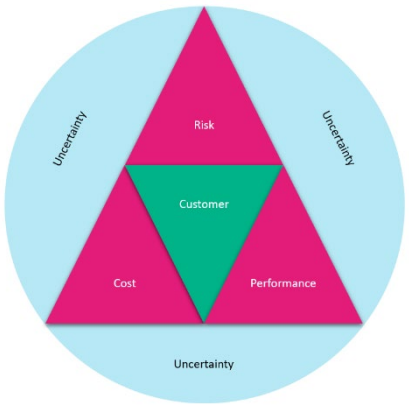
Why are we doing this work and what happens if we do nothing?

Non-Mandatory holds just over half of the risk of the Distribution Mains assets in RIIO-2 with 55% of total risk. Tier 2B holds 23%, >2" Steel has 22% and Tier 3 has 9%. The primary NARMs driver for investment is to reduce Financial risk. Failure in this group of assets may lead to an increase in reactive repair costs. A secondary driver for intervention is to reduce Carbon risk as failure in these assets may lead to the escape of Gas.

If we do nothing in RIIO-2 total Non-Mandatory risk increases by 16%. By not investing in our assets in RIIO-2 every asset will move further along its deterioration curve and the probability of failure will increase.



What is the outcome that we want to achieve? – ***We want to manage the risk we hold within this group of assets.*** We know that reliability and safety remain top of our customer's priorities and so our investments in RIIO-2 will be focussed on effectively managing these risks.



We want to ensure efficient costs. We plan to balance risk and value to deliver the optimal solution for our customers at the most efficient cost. We plan on using our C55 software to maximise the value of our investments and our Unit Cost Database tool to accurately and consistently forecast capital expenditure.

We want to improve our service levels. We plan to set constraints within C55 to ensure our investments deliver service measure improvements such as a reduction in the expected number of supply interruptions.

We want to protect our customers from future uncertainty. To ensure the investments we make in RIIO-2 are right for both our existing and future customers and to avoid the risk of asset stranding, we aim for our investments to payback within a 20-year period which is a timeframe in which we expect minimal changes in demand on our network. In addition, we will consider extending the life of existing assets wherever possible as another means of mitigating against future uncertainties.

Narrative real-life example of a problem

NGN operates a robust data-driven mechanism to identify non-mandatory pipes which may be subject to future failure using a combination of sources which may include reports from the field, statistical analysis of historic performance and input from wider stakeholders. Potential candidate projects are then assessed using CBA before being considered for approval. An example extract from an approved project submission is included below:-

BSR350252 Swinnow Lane, Leeds

This project is to replace a total of 1,234m of iron and steel mains with PE mains (948m of 12" Cast Iron, 230m 3" Steel, 55m 2" Steel and 1m of 4" Spun Iron), predominantly by open cut technique. There have been 24 escapes between 2007 and 2017 including 4 in 2017. The escapes include 6 instances of corrosion and 1 pipe fracture and there are 23 records of gas in buildings (GIB) as a result of these escapes.

This project is in an area that includes residential properties in the southern half and commercial in the north including several distribution depots. The majority of the escapes have been in the southern half, however there is no access to the Stanningley bypass / ring road, therefore all the delivery vehicles including HGV's have to use Swinnow Lane when departing the depots / offices. As a result of this any escapes can cause significant traffic disruption.

The Network Information Management (NIM) plot below shows the escape locations (green dots) and mains to be replaced highlighted

The cost estimate for this project is £459,058.62 and the payback is 11.17 years.

Spend Boundaries

This EJP covers only those mains assets which we are planning to replace under the non-mandatory category. It does not include the costs to manage these pipes prior to their replacement (e.g. escape response and repair). The proposed costs do, however, include the costs for service relays and transfers associated with the replacement of non-mandatory mains as these costs are unavoidable under HSE policy and our requirement to maintain customer supplies.

5. Probability of Failure

The Probability of Failure (PoF) is the probability an asset will fail at a given point in time. The PoF of Non-Mandatory iron and Steel pipes is calculated within the MRPS model and also within NARMs.

When justifying our RIIO-2 Investment, we use a combination of MRPS and Condition factors to identify and prioritise Pipes for potential intervention. We then combine this with our Cost Benefit Analysis, which uses the NARMS methodology, to calculate the PoF of our Non-Mandatory assets. The algorithm we use to calculate the PoF for each Failure Mode is unchanged from the NARMS methodology:

PoF = Function (Install Decade, Diameter, Material, Pressure, Distribution Zone)

This section discusses how we have used the NARMS methodology to understand the types of failure of Non-Mandatory assets as well as the rate of failure, or deterioration.

For Distribution Mains analysis has been carried out to determine the underlying relationship between mains attributes and the observed PoF. This failure data recorded not only the failed asset but the Failure Mode. The process involves the identification of statistically significant “explanatory factors” that influence the underlying rate of failure and the derivation of a mathematical relationship between the PoF and the explanatory factors for each Failure Mode. In statistical terms this is described as a counting process regression model.

We have assessed our probability of failure (and the consequent impact of choosing to replace or continue managing in service) at a deeper level than the NARMs process.

Because the Mains failure data has been referenced to individual (failed) pipes, this enables the data to be split by key explanatory factors to derive the initial PoF for each Failure Mode. The explanatory factors include:

- Asset age/installation date/decade
- Diameter
- Material
- Pressure class
- Distribution Zone

Although other mains characteristics are available, engineering experience suggests that these are the most likely explanatory factors that influence variations in the initial rate of failure (and deterioration). If other significant factors that influence failures are identified (e.g. weather/temperature), and can be related to the base asset data, the statistical model can be adapted to accommodate them.

Under NARMs, non-mandatory pipe assets are categorised at a cohort level (i.e. grouping assets by common characteristics such as material, diameter, etc.). This gives a reliable measure for the total NARM risk associated with this group. However, in order to robustly identify specific assets for replacement we need to examine the historic and forecast performance of the assets at a much more granular level than overall cohorts.

To calculate the factors to be used to amend the cohort average for non-mandatory iron pipes to the target average we have used data held within the Mains Risk Prioritisation System.
Within the MRPS model, there is a sub-calculation for each individual pipe to calculate its relative condition. This can be used as a good proxy for the NARMs cohorted risk metrics for failure but at an individual pipe level, so it can be used to calculate the relative performance of a targeted subgroup compared with the overall population.
To provide additional robustness to the analysis carried out, pipes <50m long were removed from the analysis, as short pipes looked at individually can show a very high benefit in terms of failures / km but at an undeliverable price using an average unit cost. To include these would artificially inflate the actual benefit that can be delivered for the proposed spend.

Within the NARMs model there are separate coefficients (at a cohort level) to calculate leakage probabilities based on corrosion, failure, fracture and external interference. The results of the analysis above is that, in order to better reflect the targeted populations, the coefficients to be used in the cohorted CBA model should be changed as follows:-

- Tier 2 – increase corrosion / failure / fracture factors by a multiple of 3.38
- Tier 3 – increase corrosion / failure / fracture factors by a multiple of 2.60

There is no impact on the coefficients used for external interference as these are not affected by individual pipe performance.

5.1. Probability of Failure Data Assurance

The failure models are based on various industry standard guidelines (see GDN Asset Health Risk Reporting Methodology document) and the failure rates have been statistically derived using actual asset information such as age or material and historic failure data taking into consideration other influencing factors such as weather or temperature.

Our **Core Asset Data** for Distribution Mains includes location, Diameter, Length, Material, Pressure, Failures and Risk Scores. It is scored as amber within our Data Improvement Plan for NARMS. Mains location, Pressure, material and length data is robust however, assumptions have been applied for the age of metallic distribution mains

Asset Health and Failure Data is scored as green within our Data Improvement Plan for NARMS which means our data is robust and complete. This does include some assumptions for the age of metallic Distribution Mains, but can be infilled

Our **Financial Data** is scored as green within our Data Improvement Plan for NARMS which means our data is robust and complete.

We have submitted an update to our Data Improvement Plan in 2019 which outlines how we intend to improve our data so that the Monetised Risk is reflective of our network assets and current maintenance regimes.

6. Consequence of Failure

Under the IMRRP, the principal consequence of failure (CoF) is the risk of explosion as calculated by the MRPS model. This is the primary output of the model and is used to inform the priority order for the replacement of Tier 1 pipes and also to determine if a Tier 2 pipe falls above the Risk Action Threshold and so is mandated to be replaced. This Risk value makes up part of a number of elements used to identify Non-Mandatory work that requires potential intervention/replacement

For each failure there may be a CoF which can be valued in monetary terms. In the NARMS methodology the CoF is calculated as the Probability of Consequence (PoC) multiplied by the quantity and Cost of Consequence (CoC) and are linked directly to Failure Modes which categorise the asset failure. The following consequence measures have been identified for Distribution Mains;

- Gas escape
- Gas in buildings
- Supply interruption
- Loss of gas
- Water ingress
- Explosion

Types of NARMs Consequence

The NARMS methodology sets out the Consequence Measures for each Failure Mode categorised into four risk groups: Customer Risk, Health & Safety Risk, Carbon Risk and Other Financial RIsk. These are detailed below for Offtake assets:

Risk Categories in the NGN Value Framework

We have developed a Value Framework which we use to assess the value of intervention options consistently across asset classes. We use the NARMs methodology as the basis of our Value Framework and are consistent with the Consequence Measures. However, we have recategorized them into five risk groups, not four, so that there is clear distinction between NGN and societal costs and benefits and so that the present values being calculated are correct. The five risk groups within our Value Framework are: Customer Risk, Health & Safety Risk, Environmental Risk, Compliance Risk and Financial Risk.

To derive a monetary value for the Cost of Consequence each Consequence Measure is allocated a monetary value which is multiplied by the quantity of the consequence. The monetary values used within our Value Framework are based on the agreed NARMs assumptions and uses values common across GDN's such as the base price year, industry approved values such as the cost of carbon or the social cost of an injury and values specific to our business such as the cost of maintenance or the cost of loss of supply. The quantities we use are specific to our network such as the number of domestic properties at risk of a supply interruption and have been derived from system data, network analysis or assumptions based on demands, flow and redundancy.

When justifying our RIIO-2 Non-mandatory programme the monetary value of each Consequence Measure is calculated to determine the benefit or avoided cost of an intervention. Examples include:

- **Health & Safety Risk** – Societal benefits in avoided costs through reductions in the probability of fatality or non-fatality injury. These costs are in accordance with the NARMS methodology.

- **Customer Risk** – Avoided GDN costs through a reduction in costs of supply incidents (loss of supply). These costs have been calculated from historic incidents and the probability and scale of the incidents are based on NARMs models.
- **Compliance Risk** – Avoided GDN costs through a reduction in costs of fines and paying for explosion damage. These costs are in accordance with the NARMS methodology. They have been separated from direct Financial Risk as we consider them highly uncertain and likely significantly underestimated by the values in NARMs, which does not consider reputation, legal and handling costs.
- **Financial Risk** – Avoided GDN costs through reductions in the costs to fix assets on failure and the direct financial cost of the gas leaked from and consumed by our assets. These costs are in accordance with the NARMS methodology.
- **Environmental Risk** – Societal benefits in avoided costs through reductions in the volume of carbon emitted when gas is leaked or consumed. These costs are in accordance with the NARMS methodology and industry approved values.

7. Options Considered

7.1. Options Summary

Options considered for the "Non-Mandatory Replacement" category:-

Option 1 - Manage the existing non-mandatory replacement assets by only intervening following failure (i.e. "do nothing / minimum")

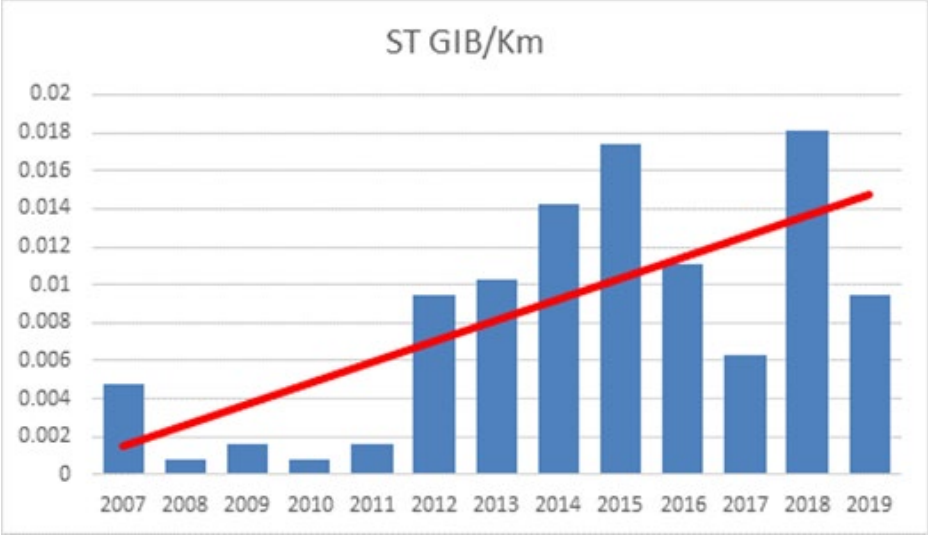
Option 2 - Carry out the proposed RIIO-2 Non-Mandatory Replacement programme

- **Tier 2B Proposal.** Our analysis shows that the failure rates for Tier 2B pipes has stabilised during RIIO-1 at 0.498 leaks per km, and so we plan to continue replacing Tier 2B at levels broadly in line with RIIO-1 at an average of 20km per year.
  Projects meeting the CBA payback period have been identified consistently throughout GD1 and analysis of the current population suggests that this will continue to deliver positive results.
  As part of this overall workload, we envisage the inclusion of some Tier 2B as part of our approach to efficient Tier 1 Mains Replacement, subject to CBA analysis.
  Our overall Tier 2B proposal for RIIO-2 shows a payback period of 16 years.

- **Tier 3 Proposal.** Recent analysis has shown that failure rates for Tier 3 pipes are significantly higher than those for Tier 2B at 1.016 leak per km and have not stabilised, suggesting that more work is required to stay ahead of deterioration on Tier 3 than we have we have previously seen in RIIO-1. As a result, and using our CBA modelling we plan to increase our Tier 3 replacement workload from 5km to 10km per year.
  As part of this overall workload, we envisage the inclusion of a small amount of Tier 3 as part of our approach to efficient Tier 1 Mains Replacement, subject to CBA analysis.
  Our overall Tier 3 proposal for RIIO-2 shows a payback period of approximately 20 years.

- **>2" Steel Proposal.** In line with both internal analysis and combined work with we have conducted with other GDNs, we see Steel as increasing Risk to the network. In 2018 NGN and the other gas networks commissioned AESL Consulting and Newcastle University to assess the performance of steel mains across the UK networks. This analysis has shown that steel mains are deteriorating at an increasing rate, and ahead of the rate at which they are being replaced. This clearly has a detrimental impact on the safety and reliability of our network. The national trend in failures from 2006 – 2018 is shown below:-

This data shows that the national rate of failure of steel in 2018 was more than double that in 2006 and is continuing to trend upwards.
The need to increase our planned steel replacement programme was further influenced by our own analysis of NGN-only data which shows that the likelihood of these escapes entering a building – and therefore creating a hazard – is also increasing over time as shown below:-



Even taking data for the more recent complete years (2011 – 2018) the trend shows GIB rates per km approximately doubling over this period.

We have therefore come to the conclusion that the appropriate level of elective > 2" steel replacement through RIIO-2 should increase to 30.6km / year. Our view is that this represents an appropriate balance between managing the current and future performance of the asset group whilst not overburdening the customers. CBA analysis shows that this has a payback period of approximately 13 years.

- **Zero Scoring Proposal.** We have a number of key single feeds in our network which have significant risk of supply issues associated with them, based on a CBA driven approach we intend to review and promote for replacement. Additionally, we envisage the inclusion of some Zero scoring mains as part of our approach to Mains Replacement where this represents the most efficient solution.

- **Other Mains Proposal.** We decommission PE where there is a known and unacceptable increased risk of failure, or where it is effective to do so as part of a holistic replacement scheme. Workload within this category is generally in line with that seen through RIIO-1.
  As part of our asset management programme, we have been assessing all of our distribution mains exposed crossings for their condition, suitability, vulnerability and resilience in terms of security of supply. These pipes may cross roads, rivers, canals railway lines, etc. Our risk analysis has shown that we need to make repex investments to replace approximately 4km of these.
  In addition, we are intending to replace pipes which are fitted with Phoenix or Paltem liners (thin plastic sheaths installed as liners to a small number of iron pipes in the 1980's). We have approximately 9km of these pipes currently in service. Should these liners fail then we currently have no proven method of working on these pipes in all situations. As these were generally fitted to larger diameter critical mains, we consider this represents an unacceptable risk to security of supply and so plan to replace these pipes in a planned way through to the end of RIIO-2.

- **Diversions Proposal.** Diversions are driven by requests from third parties to move our main or by other external factors such as landslip or river bank erosion. They can be rechargeable to the third party or non- rechargeable dependant on our legal rights covering the current position of our pipes. However, even for rechargeable pipes we may incur a net cost, for instance if we are required to apply a discount for betterment or under the provisions of the New Roads and Street Works Act (NRSWA).
  Workload has been trending up slightly mainly driven by economic factors, and analysing the number of quotes we have been responding to we expect the average workload in RIIO-2 to be slightly higher than RIIO-1 at 9.8km and 3.5km per year for rechargeable and non-rechargeable diversions respectively compared with 8.0km and 2.4km per year in RIIO-1.

- **Risers Proposal.** We proactively manage the risk on our multi-occupancy buildings (MOBs), specifically targeting areas of higher probability of failure and areas of criticality. We use an ongoing programme of surveys to regularly reassess risk and then carry out remedial work on a planned and reactive basis as required. The primary driver for our proposed GD2 investment plan for risers is to maintain the high levels of integrity, safety and reliability of these assets.
  This will be delivered by continuing with our planned inspection regime and making the appropriate investment decisions. These include:-
  - No further action required
  - Replace the asset, either due to the riser being of a non-preferred material (ductile iron, cast iron, spun iron or copper) or following inspection or a reported escape where local repair or more extensive refurbishment is not possible or suitable.
  - Carry out minor localised repair (usually patch-paint – Opex cost)
  - Carry out more extensive refurbishment
  - Carry out isolation of the riser, generally following a request from the building owner.

  Through RIIO-2 we anticipate needing to make Repex interventions (replace or extensively refurbish) on a total of 72 risers, and potentially isolate a further 155 risers.

Option 3 – Increase the proposed non-mandatory workload by +5% / +10%

We have considered this option and reviewed it using our CBA methodology. We have not considered increasing workloads for Phoenix / Paltem-lined pipes as these represent a fixed population or for Diversions as these are driven by third parties outside the control of NGN.

Option 4 – Defer all non-mandatory spend for RIIO-2.

We have considered this option and reviewed it using our CBA methodology. We have not considered deferral for Diversions as these are driven by third parties and we are obliged to respond within a reasonable timescale.

Future Energy Pathways. We have used the default assumption of current assumed proportion of methane CO2 in natural gas projected forwards due to uncertainties in the potential energy pathways and because this is reflective of the current gas quality legislation. However, we acknowledge that significant changes to gas demand or the allowed methane content of gas, for example due to the blending with or conversion to hydrogen, would impact the benefits of investment in our assets. Arup conducted analysis on the potential benefits of our H21 Programme (see A13 - NGN RIIO-2 Consumer Value Proposition) that showed 45% of the gas in our network is expected to be Natural, 15% biomethane and the remaining 40% hydrogen by 2040; due to a combination of blending and sub-areas of our networks being fully converted. This is consistent with Net-zero by 2050 aligned with the ENA Navigant report.

We have not explicitly modelled changes in the methane content of gas in our CBAs as overall gas demand and the change in C02 content of the gas is not expected to be different enough to materially impact the NPV, Payback & Option Ranking of our preferred investment programme. This is because carbon risk benefit is one element of overall risk benefit and this will be reduced by up to

40% by 2040 across all scenarios if the ambitious but realistic ENA Navigant report pathway is chosen. Our chosen programme represents value for money regardless and is mainly driven by customer benefits such as avoiding loss of supply, safety considerations & avoiding increasing disruption from repairs due to deteriorating assets. The investments also ensure that we are compliant with relevant legislation. Therefore, it represents a no regrets investment programme that is consistent with net zero and will deliver value to customers whether a hydrogen or electrification pathway is chosen.

7.2. Options Technical Summary and Cost Summary Table

Description	Asset Category	1st year of GD2 spend	Final year of GD2 spend	Annual Volume of Interventions	Investment design life	Total GD2 Repex cost (£m)	Total GD2 Repex cost (£m)
"Do Nothing"	All	N/A	N/A	0	N/A	0	0
Preferred Solution	Tier 2B	21/22	25/26	20.4km	50+ years	£37.8	£136.6
	Tier 3	21/22	25/26	10.2km	50+ years	£32.3	
	> 2" Steel	21/22	25/26	30.6km	50+ years	£25.7	
	Zero-scoring	21/22	25/26	8.4km	50+ years	£13.0	
	Other Mains	21/22	25/26	5.1km	50+ years	£13.3	
	Diversions (Net)	21/22	25/26	13.3km	50+ years	£11.6	
	Risers	21/22	25/26	45	50+ years	£2.8	
Preferred Solution +5%	Tier 2B	21/22	25/26	21.4km	50+ years	£39.7	£142.3
	Tier 3	21/22	25/26	10.7km	50+ years	£34.0	
	> 2" Steel	21/22	25/26	32.1km	50+ years	£27.0	
	Zero-scoring	21/22	25/26	8.8km	50+ years	£13.7	
	Other Mains	21/22	25/26	5.3km	50+ years	£13.5	
	Diversions (Net)	21/22	25/26	13.3km	50+ years	£11.6	
	Risers	21/22	25/26	47	50+ years	£2.9	
Preferred Solution +10%	Tier 2B	21/22	25/26	22.4	50+ years	£41.6	£148.0
	Tier 3	21/22	25/26	11.2	50+ years	£35.6	
	> 2" Steel	21/22	25/26	33.7	50+ years	£28.3	
	Zero-scoring	21/22	25/26	9.2	50+ years	£14.3	
	Other Mains	21/22	25/26	5.4km	50+ years	£13.7	
	Diversions (Net)	21/22	25/26	13.3km	50+ years	£11.6	
	Risers	21/22	25/26	49	50+ years	£3.0	

8. Business Case Outline and Discussion

8.1. Key Business Case Drivers Description

Option 1 was rejected. We have an obligation under the safety case to ensure a safe and resilient network is maintained. With no approved 're-lifing' techniques on the network we would have to manage pipes based on a fail then fix approach without a programme of planned replacement work. For larger diameter mains we can also consider the use of innovative techniques such as STASS (a robot-deployed tool allowing us to internally treat multiple pipe joints through a single operation – covered more extensively in the Innovation section). We do (and will continue to) use these options where they are the most appropriate interventions but classify them as Opex activities. To manage pipes without any planned replacement strategy would have negative impacts in terms of cost, reliability, environmental and stakeholder outcomes.

Option 2 is our preferred option. This will deliver a sustainable and efficient level of Non-Mandatory replacement. Where they are encountered as part of a replacement project, existing PE services will be transferred to the replacement main and steel services will be relaid in PE in line with our agreed procedures. We anticipate the overall workload will be split as 60% relays and 40% transfers.

Option 3 was considered but rejected for RIIO-2. This would increase our overall spend and analysis using our CBA method shows that this would deliver a worse NPV over 20 years and, based on current and forecast pipe performance through RIIO-2, we could not demonstrate that this would deliver better value for customers compared with the preferred option.

Option 4 was considered but rejected for RIIO-2 as analysis using our CBA method shows that this would deliver a consistently worse NPV.

8.2. Business Case Summary

The tables below detail the headline business case metrics to allow a high-level comparison of the options.

Tier 2B

Option No	Description	GD2 Forecast	Total NPVs compared with baseline (£m)					Preferred Option
			2030	2040	2050	2060	2070	
Baseline	Baseline	£0.00	£0	£0	£0	£0	£0	N
1	Preferred Option	£37.80	-£4.1	£6.9	£35.7	£77.4	£130.5	Y
2	Preferred +5%	£39.69	-£4.6	£6.1	£35.1	£77.4	£131.3	N
3	Preferred +10%	£41.58	-£5.2	£5.2	£34.6	£77.4	£132.1	N
4	Deferred	£0.00	-£7.6	-£18.6	-£13.2	£4.8	£32.3	N

Tier 3

Option No	Description	GD2 Forecast	Total NPVs compared with baseline (£m)					Preferred Option
			2030	2040	2050	2060	2070	
Baseline	Baseline	£0	£0	£0	£0	£0	£0	N
1	Preferred Option	£32.34	-£5.6	-£1.6	£14.5	£38.4	£67.9	Y
2	Preferred +5%	£33.96	-£6.1	-£2.4	£13.9	£38.3	£68.4	N
3	Preferred +10%	£35.57	-£6.5	-£3.1	£13.4	£38.1	£68.8	N
4	Deferred	£0.00	-£3.6	-£9.6	-£1.4	£16.0	£39.6	N

>2" Steel

Option No	Description	GD2 Forecast	Total NPVs compared with baseline (£m)					Preferred Option
			2030	2040	2050	2060	2070	
Baseline	Baseline	£0	£0	£0	£0	£0	£0	N
1	Preferred Option	£25.68	-£1.6	£9.2	£34.9	£73.6	£127.6	Y
2	Preferred +5%	£26.97	-£1.7	£9.7	£36.7	£77.4	£134.0	N
3	Preferred +10%	£28.25	-£1.8	£10.2	£38.5	£81.1	£140.5	N
4	Deferred	£0.00	-£10.1	-£28.0	-£39.1	-£43.5	-£43.9	N

Iron mains > 30m from property (Zero Scoring)

Option No	Description	GD2 Forecast	Total NPVs compared with baseline (£m)					Preferred Option
			2030	2040	2050	2060	2070	
Baseline	Baseline	£0	£0	£0	£0	£0	£0	N
1	Preferred Option	£13.02	-£1.9	£0.9	£9.6	£22.9	£40.7	Y
2	Preferred +5%	£13.67	-£2.0	£0.7	£9.4	£22.9	£41.0	N
3	Preferred +10%	£14.32	-£2.2	£0.4	£9.2	£22.8	£41.1	N
4	Deferred	£0.00	-£2.2	-£5.8	-£3.8	£2.7	£13.0	N

PE Mains

Option No	Description	GD2 Forecast	Total NPVs compared with baseline (£m)					Preferred Option
			2030	2040	2050	2060	2070	
Baseline	Baseline	£0	£0	£0	£0	£0	£0	N
1	Preferred Option	£3.49	-£1.3	-£2.4	-£2.9	-£3.1	-£3.1	Y
2	Preferred +5%	£3.66	-£1.3	-£2.6	-£3.1	-£3.3	-£3.3	N
3	Preferred +10%	£3.84	-£1.4	-£2.7	-£3.2	-£3.4	-£3.5	N
4	Deferred	£0.00	-£4.9	-£17.2	-£30.4	-£42.1	-£52.1	N

Phoenix / Paltem Lined Pipes

Option No	Description	GD2 Forecast	Total NPVs compared with baseline (£m)					Preferred Option
			2030	2040	2050	2060	2070	
Baseline	Baseline	£0	£0	£0	£0	£0	£0	N
1	Preferred Option	£3.56	-£0.9	-£1.1	-£0.3	£1.1	£2.9	Y
4	Deferred	£0.00	£0.0	£0.0	£0.0	£0.0	£0.0	N

Risers

Option No	Description	GD2 Forecast	Total NPVs compared with baseline (£m)					Preferred Option
			2030	2040	2050	2060	2070	
Baseline	Baseline	£0	£0	£0	£0	£0	£0	N
1	Preferred Option	£2.81	-£0.6	-£0.7	£0.0	£1.4	£3.4	Y
2	Preferred +5%	£2.94	-£0.6	-£0.7	£0.0	£1.5	£3.6	N
3	Preferred +10%	£3.03	-£0.6	-£0.7	£0.1	£1.6	£3.8	N
4	Deferred	£0.00	-£0.5	-£1.7	-£2.0	-£1.6	-£0.7	N

9. Preferred Option Scope and Project Plan

9.1. Preferred Option

The preferred option is Option 2

9.2. Spend and Workload Profile

Throughout GD2 we anticipate being able to deliver an ongoing efficiency cost reduction of 0.5% year-on-year. We also anticipate that the "other services" workloads and associated costs will gradually decline through the period as steel services are replaced as part of our ongoing mains replacement activities.

The table overleaf details the preferred option's workload and expenditure profile through RIIO-2:

	21/22	22/23	23/24	24/25	25/26	GD2 Total
Tier 2B Mains & Associated Services						
Mains (km)	20.4	20.4	20.4	20.4	20.4	**102**
Services (interventions)	531	531	531	531	531	**2655**
Cost (£m)	7.6	7.6	7.6	7.5	7.5	**37.8**
Tier 3 Mains & Associated Services						
Mains (km)	10.2	10.2	10.2	10.2	10.2	**51**
Services (interventions)	280	280	280	280	280	**1402**
Cost (£m)	6.5	6.5	6.5	6.4	6.4	**32.3**
>2" Steel Mains & Associated Services						
Mains (km)	30.6	30.6	30.6	30.6	30.6	**153**
Services (interventions)	2071	2071	2071	2071	2071	**10353**
Cost (£m)	5.2	5.2	5.1	5.1	5.1	**25.7**
Iron Mains & Associated Services >30m						
Mains (km)	8.3	8.3	8.3	8.3	8.3	**41.6**
Services (interventions)	0	0	0	0	0	**0**
Cost (£m)	2.6	2.6	2.6	2.6	2.6	**13**
Other Mains & Associated Services						
Mains (km)	5.1	5.1	5.1	5.1	5.1	**25.5**
Services (interventions)	150	150	150	150	150	**750**
Cost (£m)	2.7	2.7	2.7	2.7	2.6	**13.3**
Diversions						
Mains (km)	13.3	13.3	13.3	13.3	13.3	**66.4**
Services (interventions)	266	266	266	266	266	**1329**
Net cost (£m)	2.3	2.3	2.3	2.3	2.3	**11.6**
Total Non-Mandatory Mains & Associated Services						
Mains (km)	75.1	75.1	75.1	75.1	75.1	**439.5**
Services (interventions)	3068	3068	3068	3068	3068	**16488**
Cost (£m)	27.0	26.9	26.8	26.6	26.5	**133.8**
Risers						
Cost (£m)	0.6	0.6	0.6	0.6	0.6	**2.8**

9.3. Investment Risk Discussion

The most significant risks that we envisage are a failure to have adequate resources (numbers, skills, location) to complete the work and failure to have access to the required locations.

Although our proposed non-mandatory workload is increasing for >2" steel and Tier 3 compared with RIIO-1, our mandatory Tier 1 iron volume is falling. Our DSP contracting strategy is robust and stable, working directly with and providing support to the individuals, teams and organisations actually involved with doing the projects which, combined with our flexible BOL / Totex approach means that we don't foresee issues with resource availability. Our regionally-based BOL model means that we have developed closer local relationships with Councils and roads authorities. On top of this, we have a strong track record through RIIO-1 of actually delivering on our plans in terms of both length and diameter mix. Because of these we are confident that our RIIO-2 plan for mandatory replacement is robust and deliverable as proposed.