Annex A14.18

Structural Integrity Engineering Justification Paper

December 2019

As a part of the NGGT Business Plan Submission

nationalgrid

Executive Summary

Introduction

To maintain the ongoing safe, secure and reliable operation of the UK Gas National Transmission System (NTS) it is imperative that the health of the assets that constitute the NTS is carefully managed.

Our Asset Health programme is an ongoing plan of works that assures this and consists of 7 core asset themes of work. This document outlines our approach to the management of our Structural Integrity assets to meet desired regulatory, stakeholder and financial outcomes. A 10-year view has been taken, covering the RIIO-2 and RIIO-3 regulatory periods to ensure a balanced, lifecycle approach to asset management.

The Structural Integrity assets support our pipelines and sites to ensure they are safely operated, protected and limit the environmental impact of our assets. As such their continued provision of a basic required level of performance is necessary, with the most critical elements such as buildings, concrete foundations and pipe supports being essential. In some cases, these support compliance with the Pipeline Safety Regulations (PSR), as well as some environmental obligations. For site security, we have a duty of care to ensure both the public and employees are protected and therefore we need to ensure our sites are safe and secure.

The Structural Integrity asset health programme is split across 3 sub-themes. In total, we propose to spend £79.5m (12.9% of the 7 themes that comprise the overall asset health plan) ensuring risk levels are maintained on our Pipeline assets during RIIO-2.

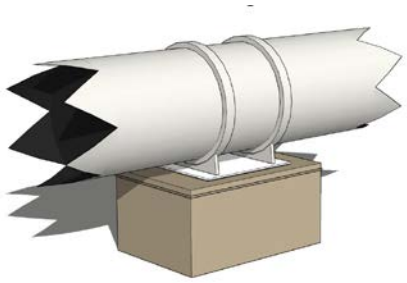
Sub-theme	Intervention Volumes	Cost
Pipe Supports/ Pits and Ducting	1,757	£39,287,182
Security and Fencing, Access and Buildings	1,613	£33,685,071
Treatment and Drainage, Tanks and Bunds	729	£6,564,960
Total	**4,099**	**£79,537,213**

The profile of Structural Integrity asset health investment for the 10-year period, derived from the volumes of work and the unit costs, is shown in the table below:

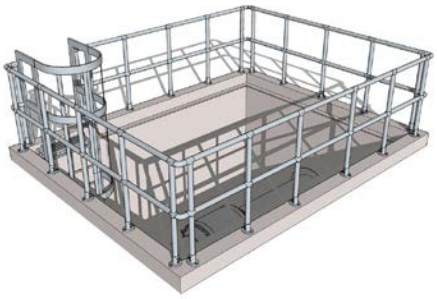
Investment (£ 000's)	RIIO-2					RIIO-3				
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Total	7,020	9,600	19,464	22,005	21,449	26,645	27,842	30,051	28,657	26,009
	79,537					**139,205**				

The Assets

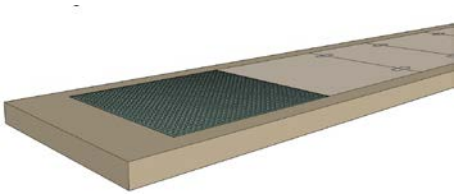
The Structural Integrity theme consists primarily of **Pipe Supports and Pits** that ensure pipework is accessible and imposed stresses are limited, **Ducting** that provides a safe routing for pipework and cabling, **Security and Fencing** to protect assets from breaches by external parties, **Access** allowing movement around sites, **Buildings** in a range of sizes and functions, **Tanks and Bunds** providing liquid containment and **Sewerage Treatment and Drainage** to stop pollution leaving the site and flooding occurring.



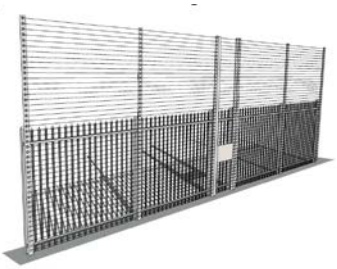
Pipe Supports



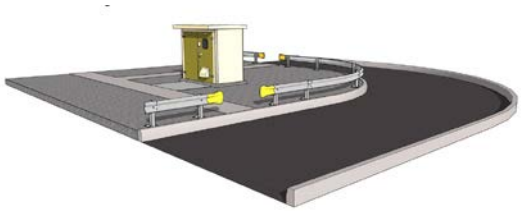
Pits



Ducting



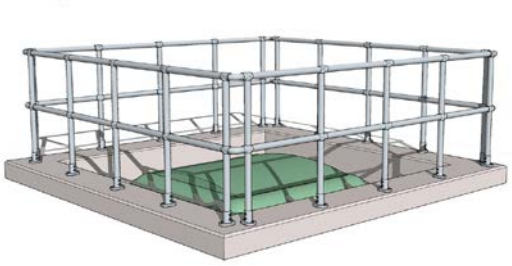
Security Fencing & Gates



Site Access

Buildings

Storage Tanks



Sewerage & Drainage

In this document the Structural assets have been grouped as follows:

- Supports, Pits and Ducting - protecting the primary assets,
- Security, Fencing, Buildings and Access - ensuring the primary assets are secure
- Tanks, Bunds, Sewage Treatment and Drainage - protecting the environment

As such the continued provision of a basic required level of performance is necessary, with the most critical elements such as buildings, concrete foundations and pipe supports being

essential. In some cases, these support compliance with the Pipeline Safety Regulations (PSR), as well as some environmental obligations.

Impacts of No Investment

As many of the NTS sites are now older than their original design lives, an increase in failure of the structural integrity assets is to be expected, with an increasing need for assessment and re-lifing. Many assets are reinforced concrete and are subject to age-based deterioration, signs of which are often visible, in the form of cracks and delamination. Not investing at this stage can lead to further severe deterioration where spalling occurs, at which point the safety and structural integrity of the asset is prejudiced, and the cost of repair dramatically increases. This principle applies to assets constructed of other materials such as roads, security fencing and access platforms.

External factors such as weather and ground movement impact the integrity of the structural assets and can consequentially affect critical operational equipment. Failure of assets associated with site access can impede critical maintenance which in turn can affect the operational reliability of the primary NTS assets.

It should also be noted that good access routes, ladders and platforms are essential for safe working on sites, and access roads are often used by members of the public with the attendant duty of care.

Within the structures remit is also containment and treatment facilities for required liquid consumables and for dealing with waste water. Failure to manage deterioration of these assets would undermine our ability to meet the requirements of fire response plans and environmental discharge permits as well as continued operation.

Proposal Development

In defining our proposed intervention approach, we have focused our effort on developing a least whole-life cost option that enables an optimised ongoing, rolling programme of work. Significant expert challenge and review has underpinned the levels of intervention, and the proposed phasing ensures we meet the desired engineering and stakeholder outcomes whilst smoothing out the workload.

Only the Security Fencing, Access and Buildings sub-theme shows an overall cost benefit. The Pipe Supports, Pits & Ducting sub theme and the Treatment, Drainage, Tanks and Bunds sub theme proposed interventions are not cost beneficial under our CBA methodology, however they do deliver on the desired outcomes, shown in the table below. For these sub themes of work, we have selected the most cost-beneficial options, applying a best-practice whole life approach.

Within the Pipe Supports & Ducting area, it is proposed to replace all 64 spring hangers as they are essential for managing the vibration and induced stresses of site pipework to reduce the possibility of failure.

Security, Access & Buildings must address many age-related challenges including leaking flat roofs, potholed roads and asbestos removal which are essential for protecting other equipment and ensuring a suitable and safe working environment.

Tanks, Treatment & Drainage has challenges with corrosion of steel tanks, plastic tanks that are at end of life and concrete bunds that are suffering from corrosion of their reinforcing bars, as well as obsolete and deteriorating drainage and waste water treatment facilities, all of which are necessary to manage safety and environmental risks and comply with legislation.

In choosing the option to be carried forward into our plan we have considered the results of our CBA analysis amongst a range of other factors, examples set out below:

- The need to achieve legislative compliance may not necessarily be reflected through the quantified benefits delivered through a cost beneficial investment option. For example, the [redacted] will not tolerate a planned increase in safety risk, regardless of the economics.
- Where there is a backlog of known asset failures to be resolved, this will not always be reflected by the CBA as the risk valuation is calculated using an expected rate of future defects across the whole population of an asset type. This means that the risks of no action are undervalued by the approach and greater intervention is required to address the known defects.
- Our understanding of individual asset condition has improved during RIIO-1 but there are still gaps in our knowledge. Our plan reflects the need for a likely practical mix of intervention categories once specific assets are surveyed and their true condition and risk are understood. For example, a plan based upon 100% refurbishment may require a high number of replacements should a proportion of the assets be determined as non-serviceable

Where proposed investments are not cost-beneficial we have used our experience and asset management expertise to put forward the best mix of interventions to deliver customer and stakeholders expectations.

The table below summarises the key considerations when developing this theme of work.

To deliver these outcomes….
• Meet legal requirements and agreed safety and environmental standards • Provide a safe working environment for all our staff and maintain our duty of care to members of the public • Ensure pipe supports, pits and buildings do not affect the long-term availability, safety and performance of the NTS including the compressors and AGIs. • Mitigate the safety risks associated with all the corroded spring hangers, deteriorating ducting, access roads and pavements • Ensure the risk of flooding and pollution from hazardous liquids on NTS sites is managed and that we maintain compliance with all Pollution Prevention and Control (PPC) Permits through effective foul drainage and sewage treatment. • Maintain reliable energy supplies across the NTS • Meeting the expectations of our customers and stakeholders and keeping risk stable
…by intervening like this…
• Using a survey programme to identify defects, capture specific high-quality data and categorise them using 3 grades • Conducting inspections of all significant retaining walls, geotechnical slopes and potential structural defects in assets such as buildings • Addressing the operational, environmental and safety risk associated with obsolete systems and equipment • Applying a risk-based assessment of the defects identified to proactively or reactively address the defects as appropriate and refocus monitoring

- Ensuring compliance with legal requirements and all relevant regulations and approved codes of practice

…based on this knowledge:

- Historical inspection and monitoring results for the assets.
- A consistent condition grading system.
- An asset-specific risk-based review of the results of routine inspections, maintenance and investigations already undertaken
- The pipe-stress analysis and pipe support design
- The physical security requirements at each site
- The requirements of our PPC Permits as applied at each site
- The emergency response plans at each site
- Knowledge of the volumes of assets that are currently obsolete or forecast to be obsolete during the investment period.

RIIO-2 Structural Integrity Asset Health Investment Proposal Summary

Structural Integrity Asset Health investment proposal headlines:

- The total RIIO-2 proposed expenditure for this theme is £79.5m, which is broadly consistent with spend levels in RIIO-1.
- 99% of our Structural Integrity programme is based upon interventions to address known defects (17%) and high confidence work volumes based on historical trends (82%).
- None of the Structural Integrity investments are included in our NARMs model. Price Control Deliverables will be agreed on the significant areas of this proposal to assure the outputs are delivered
- Spend is forecast to increase in RIIO-3 as we have taken the view that we will manage the risk through operational means and risk mitigation practices can be deployed where appropriate
- Our CBA tests are difficult to pass for this type of work, due to the indirect role of these assets in the conveyance of gas, and the CBA does not recognize all the key benefits of undertaking the work e.g. safety compliance, however 42% is cost beneficial

A range of options has been considered for each sub-theme of the Structural Integrity interventions:

Sub-theme	RIIO-2 Plan (£)	Percentage of Theme	Options considered	Option summary / considerations
Pipe Supports/ Pits and Ducting	£39,287,182	49.4%	5	Range of options identified to balance cost/risk detailed within this justification report. Chosen option takes a risk based re-life approach to maintain stable risk
Security and Fencing, Access and Buildings	£33,685,071	42.4%	5	Range of options identified to balance cost/risk detailed within this justification report. Chosen option takes a risk based re-life approach to maintain stable risk

Treatment and Drainage, Tanks and Bunds	£6,564,960	8.3%	5	Range of options identified to balance cost/risk whilst maintaining environmental compliance detailed within this justification report. Chosen option takes a risk based re-life approach to maintain stable risk.

We have estimated unit costs across all our proposed Structural Integrity interventions either from historical outturn data points, from supplier quotations or from other estimation methods (such as extrapolation to similar types of work or from reviewing industry benchmarking data). Our approach has been primarily based top down from final actual costs combined with bottom up from estimating procedures and supplier rates or quotations. We have challenged our costs through internal benchmarking review with current supply chain partners combined with use of benchmarking data where this exists.

All the unit costs include the efficiencies resulting from bundling delivery programmes across asset classes and within available outages and efficiencies resulting from our innovation projects where these are proven to deliver benefits and can be utilised in the planned investments.

60% of costs for the Structural Integrity assets in our plan are supported by outturn costs which provides a medium level of confidence overall. The remaining 40% is supported by other estimation methods due to limited supplier quotations available. There are cost differentiators (e.g. ground conditions and intervention type) and unique factors (e.g. access requirements and work mix) that influence the degree of certainty, which are presented in this report.

The table below summarises the evidence used to produce the Structural Integrity unit costs.

Investment sub-theme	Secondary Asset Class	RIIO-2 Business Plan	Evidence		
			Outturn	Estimated - Quotation	Estimated - Other
Pipe supports/Pits and Ducting	Ducting	[redacted]	72%	0%	28%
	Pipe Supports and Pits	[redacted]	41%	0%	59%
Security and Fencing, Access and Buildings	Access	[redacted]	71%	0%	29%
	Buildings and Enclosures (except for Cab Infrastructure)	[redacted]	0%	0%	100%
	Security & Fencing	[redacted]	94%	0%	6%
Sewage Treatment and Drainage, Tanks and Bunds	Sewage Treatment & Drainage	[redacted]	69%	0%	31%
	Fuel tanks and bunds	[redacted]	78%	0%	22%
Total		[redacted]	60%	0%	40%

We have set out full details of our process for estimating unit costs across our asset health proposals in our Asset Health Unit Cost Annex.

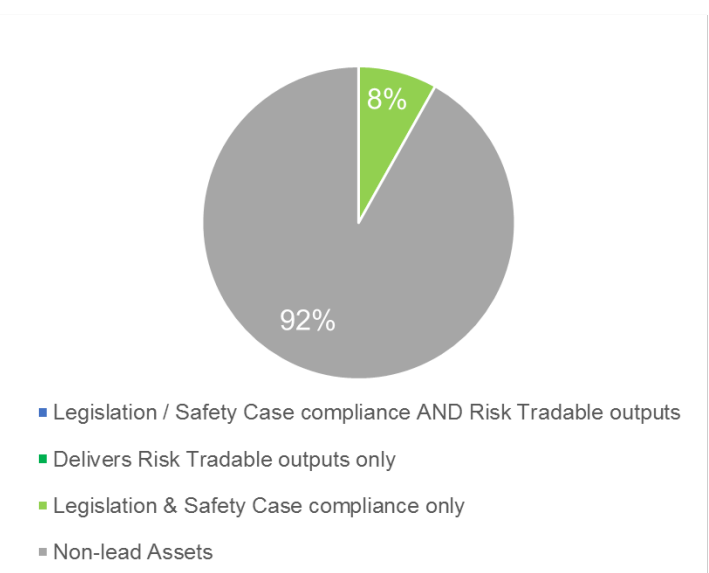
The RIIO-2 Asset Health Structural Integrity theme and intervention costs and volumes by output are provided below. All costs are in thousands (£000s).

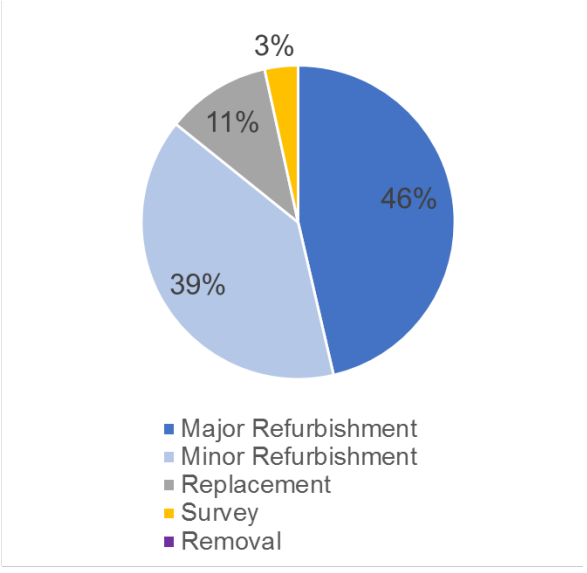
Sub-theme & Intervention	RIIO-2 Volumes[1]	Legislation/ Safety Case & Risk Tradable	Risk Tradable	Legislation & Safety Case	Non-lead Assets
Pipe Supports/ Pits and Ducting					
Minor remediation works	[redacted]	£0	£0	£0	£1
Monitoring of Structural Integrity Assets	[redacted]	£0	£0	£0	£1
Major remediation works	[redacted]	£0	£0	£0	£5
Minor remediation works	[redacted]	£0	£0	£0	£36
Monitoring of Structural Integrity Assets	[redacted]	£0	£0	£0	£90
Major remediation works	[redacted]	£0	£0	£0	£66
Monitoring of Structural Integrity Assets	[redacted]	£0	£0	£0	£107
Relifing of Pipe Supports & Pits at Compressor Sites (Concrete)	[redacted]	£0	£0	£0	£1,942
Relifing of Pipe Supports & Pits at Compressor Sites (Hydro Demolition)	[redacted]	£0	£0	£0	£11,179
Relifing of Pipe Supports & Pits at AGIs - Replace Concrete pipe supports	[redacted]	£0	£0	£0	£7,289
Relifing of Pipe supports and pits AGI sites - Inspect, Remove Frame & Cover & Backfill	[redacted]	£0	£0	£0	£1,985
Relifing of Pipe supports and pits AGI sites - Remove Chamber Walls, Inspect & Backfill	[redacted]	£0	£0	£0	£8,275
Minor remediation works	[redacted]	£0	£0	£0	£54
Relifing of Site Ducting	[redacted]	£0	£0	£0	£1,384
Monitoring of Structural Integrity Assets	[redacted]	£0	£0	£0	£301
Minor remediation works	[redacted]	£0	£0	£0	£151
Relifing of Pipe Supports & Pits at Compressor Sites (Steel)	[redacted]	£0	£0	£0	£1,248
Relifing of Pipe Supports at AGIs – Replace Steel pipe supports	[redacted]	£0	£0	£0	£4,014
Replacement of Pipeline Spring Hangers at Compressor Sites	[redacted]	£0	£0	£0	£797
Mitigation of Settlement	[redacted]	£0	£0	£0	£0
Damaged ducting covers – Replacement (St Fergus)	[redacted]	£0	£0	£0	£361
Security and Fencing, Access and Buildings					
Minor remediation works	[redacted]	£0	£0	£0	£89
Monitoring of Structural Integrity Assets	[redacted]	£0	£0	£0	£222
Major remediation works	[redacted]	£0	£0	£0	£791
Minor remediation works	[redacted]	£0	£0	£0	£91
Monitoring of Structural Integrity Assets	[redacted]	£0	£0	£0	£228
Major remediation works	[redacted]	£0	£0	£0	£811
Monitoring of Structural Integrity Assets	[redacted]	£0	£0	£0	£416
Minor remediation works	[redacted]	£0	£0	£0	£399
Security - Fences and Gates - AGI (Minor Works)	[redacted]	£0	£0	£0	£14,257
Security - Fences and Gates - Compressor	[redacted]	£0	£0	£0	£4,377
Minor remediation works	[redacted]	£0	£0	£0	£208
G2/G3 Access Platforms & Stairs Relifing	[redacted]	£0	£0	£1,178	£0
Site Access Roads and Paths Major Refurb	[redacted]	£0	£0	£0	£7,801
Monitoring of Structural Integrity Assets	[redacted]	£0	£0	£0	£328
Minor remediation works	[redacted]	£0	£0	£0	£164
Buildings & Enclosures at AGIs Major Refurb	[redacted]	£0	£0	£0	£0
Relifing of Buildings & Enclosures at Compressor Sites	[redacted]	£0	£0	£0	£1,237
Monitoring of Structural Integrity Assets	[redacted]	£0	£0	£0	£798

[1] Where 'rounding' has resulted in volumes being presented as a zero, we have included a decimal place to illustrate the proportion of investment phased in RIIO-2 (remainder in RIIO-3).

Access Road Monitoring & Replacement (St Fergus)	[redacted]	£0	£0	£0	£289
ISS software, cameras and monitors – Replacement (St Fergus)	[redacted]	£0	£0	£0	£0
Treatment and Drainage, Tanks and Bunds					
Minor remediation works	[redacted]	£0	£0	£5	£0
Monitoring of Structural Integrity Assets	[redacted]	£0	£0	£0	£13
Relifing or Replacement of Tank Bunds	[redacted]	£0	£0	£28	£0
Minor remediation works	[redacted]	£0	£0	£25	£0
Monitoring of Structural Integrity Assets	[redacted]	£0	£0	£0	£63
Major remediation works	[redacted]	£0	£0	£135	£0
Monitoring of Structural Integrity Assets	[redacted]	£0	£0	£0	£554
Minor remediation works	[redacted]	£0	£0	£0	£277
Damaged and Broken Drainage Assets at AGIs Minor Refurb	[redacted]	£0	£0	£2,381	£0
Replace Obsolete Sewage Treatment Assets at Compressor Sites	[redacted]	£0	£0	£773	£0
Monitoring of Structural Integrity Assets	[redacted]	£0	£0	£0	£235
Minor remediation works	[redacted]	£0	£0	£0	£117
Relifing or Replacement of Tank Bunds	[redacted]	£0	£0	£1,563	£0
Damaged and broken drainage assets – Replacement (St Fergus)	[redacted]	£0	£0	£361	£0
Relifing or Replacement of Tank Bunds (St Fergus)	[redacted]	£0	£0	£36	£0
Total	[redacted]	**£0**	**£0**	**£6,483**	**£73,053**

Structural Integrity Asset Health theme outputs and intervention categories:

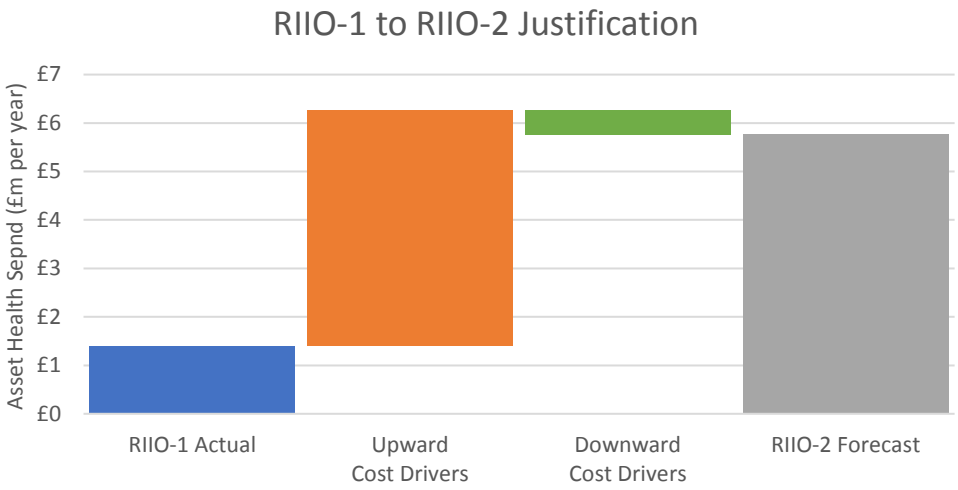




Comparing our RIIO-2 proposal to our RIIO-1 programme

The annualised RIIO-2 spend has increased when compared to RIIO-1, from £14.3m to £14.6m for the Structural Integrity Asset Health theme.

Note that this cost information is annualised to provide a comparative cost per year and the total RIIO-2 forecast below also includes the application of our agreed efficiency target within the downward drivers.



Upward Drivers

There are minor upward cost drivers related to increased volumes of work compared with RIIO-1. Our RIIO-2 plan is based on known defects – there are significant known end of life issues across the network that require resolution.

Downward Drivers

We continue to bundle structural integrity work with AGI renovation work. Our NARC programme has a proven track record of delivering this work on time and budget.

Enhancements to our unit costing and long term planning processes and systems through our change program “Richmond” will support the potential for longer term contracting for this type of work generating consistency in delivery and ongoing delivery contract performance improvements.

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1. Summary Table

Name of Scheme/Programme	*Structural Integrity*
Primary Investment Driver	*Asset Health*
Scheme reference/ mechanism or category	*A22.18*
Output references/type	*-*
Cost	*£79.5m*
Delivery Year	*2022-2026*
Reporting Table	*3.03b*
Outputs included in RIIO-1 Business Plan	*-*

2. Introduction

2.1. This document sets out our Asset Health Plan for the Structural assets that are integral to the operation of the NTS. This asset theme comprises over 50,000 individual items consisting primarily of Pipe Supports and Pits that ensure pipework is accessible and imposed stresses are limited, Ducting that provides a safe routing for pipework and cabling, Security and Fencing to protect assets from breaches by external parties, Access allowing movement around sites, Buildings in a range of sizes and roles, Tanks and Bunds providing liquid containment and Sewerage Treatment and Drainage to stop pollution leaving the site and flooding occurring.

Structure of the Case

2.2. Justification for the required investment in structural assets installed on the High-Pressure Gas National Transmission System (NTS). All the assets have been assessed using a consistent overall risk based analytical framework.

2.3. The investment case for Structural Integrity is organised into three groups.

- Those that support or protect our operational assets
    - Pipe Supports, Pits and Spring Hangers
    - Ducting
- Those that protect our assets or ensure our duty of care to staff and members of the public
    - Security
    - Access
    - Buildings
- Those that ensure environmental compliance or mitigate the risks of environmental damage to our assets
    - Sewage Treatment and Drainage
    - Tanks and Bunds

2.4. The groups enable the assets with similar drivers, purpose and impacts to be discussed and assessed collectively.

2.5. For each group of assets, the following structure has been followed:

- **Equipment summary** – which provides a summary and profile of the asset base
- **Problem statement** – the issues facing the assets, drivers for investment and impact of no investment
- **Probability of failure and Probability of consequence** – sections which set out the way the assets fail and the subsequent stakeholder impacts
- **Options considered** – the potential mix of interventions to be considered for each of the assets within a range of programmes with differing objectives

- **Business case outline and discussion** – the preferred programme option and reasons, given the cost benefit analyses and assessment of other drivers, stakeholder requirements and business objectives
- **Preferred option and plan** – the final selected option restated, along with the spend profile

Overview of the Structural Assets

2.6. Structural assets are a widely variable asset base whose role is to provide safe support and protection to critical gas transmission assets, as well as enabling safe access 24/7 in all weather conditions.

2.7. Many elements of the structural integrity assets are suffering severe deterioration to the point where they are compromising the safety, security integrity of our assets as well as risking our compliance with environmental permits A proactive intervention programme is required to ensure that unmanageable levels of degradation, together with the associated increase in whole life costs, adverse impacts on the safety, operation and availability of the NTS and any potential legislative non-compliance can be avoided.

2.8. There are over 50,000 individual assets present on all sites across the asset base and consist primarily of:

- **Pipe Supports and Pits** – provide the structural support for any above ground pipe work, and include support plinths, access pits, spring-hangers, pit-wall transitions, retaining walls and geotechnical structures
- **Ducting** – provides safe routing of instrumentation and electrical cabling and pipe work from instrument housings and control rooms to plant located around the site
- **Security and Fencing** – protect our assets from breaches by external parties; the level of protection required is dependent upon site criticality and risk, some require CCTV, electric gates and others include electrification of the fence.
- **Access -** allows safe access to and around the site and consists of roads and pavements; fixed access platforms, stairs and ladders; permanently fixed lifting equipment
- **Building** - range from instrumentation rooms and workshops, through large enclosures protecting significant plant down to smaller kiosks for quality and control assets
- **Sewage Treatment and Drainage –** stops untreated liquid pollution leaving site and prevent flooding of areas of the sites and maintains structural integrity of the ground avoiding problems such as settlement or liquefaction
- **Tanks and Bunds** – provide liquid containment around tanks to prevent pollution in the event of a tank failure or other spillage, these include waste oil tanks as well as lubrication oil and diesel tanks

2.9. Our primary investment driver for structural assets is to ensure we maintain our statutory obligations relating to Health and Safety in the workplace, specifically, enabling safe access to maintain equipment within buildings, pits and kiosks,

minimising as far as reasonably practical, hazards including; trips, falls and exposure to harmful environmental conditions such as asbestos.

2.10. The civil structural assets provide safe support and protection to our operational assets. As such their continued provision of the basic level of performance with the most critical elements such as buildings, concrete foundations and pipe supports being essential, in some cases ensuring compliance of our obligations under PSR.

2.11. Compliance with other environmental legislation and permits is also enabled by these assets.

2.12. As many of the NTS sites are now older than their original design lives, an increase in failure of the structural integrity assets is to be expected, with an increasing need for assessment and re-lifing. Many assets are reinforced concrete and are subject to age-based deterioration, signs of which are often visible, in the form of cracks and delamination. Not investing at this stage can lead to further severe deterioration where spalling occurs, at which point the safety and structural integrity of the asset is prejudiced and the cost of repair dramatically increases. This principle applies to assets of other materials such as roads, security fencing, access platforms etc. where early and more easily rectifiable wear and tear and corrosion if left will lead to significantly increased cost of remediation and higher whole life cost.

2.13. External factors such as weather and ground movement impact the integrity of the structural assets and can affect the critical operational assets, for example saturated ground due to high water table at sites such as Kings Lynn and Avonbridge Compressor stations, when combined with vibration has resulted in ground liquefaction and significant settlement of pipelines and valves.

2.14. All sites on the NTS have civil engineering elements which are collectively defined as ‘structural integrity assets’; these include a very varied range of assets, such as; foundations, support slabs, valve pits, fencing, roads, retaining walls and ‘compressor cab’ buildings, bridges and sewage treatment plants. These structural integrity assets are normally the oldest part of any site, as they were often built first and typically have the longest design life of any assets on site.

2.15. Many are essential to ensure compliance with PSR requirements associated with the integrity of high-pressure gas assets, e.g. pipeline supports, pit structures, etc.

2.16. NG need to ensure we maintain our statutory obligations relating to Health and Safety in the workplace, specifically, enabling safe access to maintain equipment within buildings, pits and kiosks, minimising as far as reasonably practical, hazards including; trips, falls and exposure to harmful environmental conditions such as asbestos.

2.17. At NG sites that are shared with other operators and customers NG have the added responsibility to provide a safe working environment, even when we are not present to manage site risks. Some of the NG sites have long access roads that are external to the site fence boundary. These are therefore subject to public use and NG have a duty of care to the public and environment to maintain these to a safe and acceptable standard.

2.18. Structural assets need to continue to provide the basic level of performance with the most critical elements such as buildings and concrete foundations and pipe supports

being essential. Other than buildings, most structural integrity assets do not require regular maintenance.

2.19. It is essential that 'Structural Integrity' assets continue to perform their role of providing safe support to critical gas transmission assets, as well as enabling safe access 24/7 in all weather conditions. This requires ensuring the structural integrity of routine assets such as access roads and platforms, through to structural slopes and retaining wall stability, failure of any of these having significant safety and reliability implications.

2.20. Levels of availability / reliability risk are not used as a method of assessment due to the long asset life and the fact it is an irregular situation that would lead to a structural Integrity asset failing to the point of making the primary asset unavailable. Typical examples are;

- Drainage failure leading to soil saturation and liquefaction of ground resulting in significant settlement of structures and pipelines
- Retaining wall movement creating collapse risks and failure of support to pipelines and buildings
- Environment Agency enforcement action due to bund failure resulting in pollution of watercourses
- Failure of through wall pipe transitions allowing ingress of water and fine material, leading to pipeline corrosion, settlement of ground and pipeline supports, with the ultimate result of pipeline failure

2.21. In addition to age the following factors are increasing the likelihood of failure and/or, the need for appropriate mitigation works to Structural Integrity assets;

- The potential impact of the structural assets can change depending upon the weather conditions. What are considered as small potholes in good conditions, are a much more significant risk in adverse conditions, which is the typical time when we need to get to and operate our sites safely, often by staff who are not necessarily familiar with the site layout. Consider these assets when there is even a modest 30mm snow cover and at night; trip-hazards are invisible, potholes are full of water and frozen over, etc.
- Increasing frequency of severe weather events e.g. flooding, overheating of buildings and drought causing ground settlement and structural damage. Examples include an instrumentation kiosk at Moffat where digital equipment tripped out due to high room temperature, shutting the site operation down. A permanent air conditioning system has been installed to provide heat and cooling, ensuring the correct temperature range is maintained for the equipment. Saturated ground due to high water table at sites such as Kings Lynn and Avonbridge Compressor stations, when combined with vibration has resulted in ground liquefaction and significant settlement of pipelines and valves
- Statutory requirements for safe working environments demand that wherever practical, risks should be eliminated or mitigated. As alternative and new solutions are available, there is a statutory expectation that such measures are used. An example is small valve access pits where it is no longer acceptable to allow man access for valve replacement, maintenance and pipe-wall transition

seal inspection. Removal of the pit is a reasonable alternative which eliminates the risk. A more modest example is raised platforms. To date, these assets have been risk assessed and the medium and high-risk access assets had basic mitigation measures installed, typically the installation of self-closing gates. This work needs to be progressed to ensure all reasonable mitigation measures are installed, in some cases requiring conversion from ladders to stair access

3. Overall Approach for Management of the Structural Integrity Assets

3.1. The available options for asset management of the ageing structural integrity assets are;

- **Do-minimum 'Reactive only':** Responding to asset failure and reports of obvious signs of near failure, e.g. cracks in concrete, leaking bunds, unsafe access, settlement/movement, etc.
- **Pro-active risk based:** Limit works to active repair, monitoring and inspection regime to enable planned mitigation and repair works to avoid asset failure, unsafe working environments and environmental damage
- **Pro-active risk based with a reactive works provision:** As 2. above but with a planned arrangement to enable an efficient response to failures of assets which are not part of the pro-active risk-based strategy but will inevitably arise due to the age and hidden nature of many structural integrity assets

3.2. This proposed investment for the period is based on option 3 on the basis that it provides the most efficient and professional approach to the management of structural integrity assets. This strategy is based on the proven approach used in RIIO-1 and ensures the efficient use of outages and resources, including costs. The alternative ad-hoc approach, resolving or mitigating numerous issues with considerable wasted resources expended on management, agreeing outages, site supervision, contract management, etc.

3.3. Active inspection, monitoring and investigation enables planned mitigation and repair works to avoid asset failure, unsafe working environments and environmental damage but with a planned arrangement to enable an efficient response to failures of assets which are not part of the proactive prioritised strategy but will inevitably arise due to the age and hidden nature of many structural integrity assets.

This approach is considered as best practice in the management of structural assets.

Inspection, Monitoring and Investigation

3.4. The foundation of the approach for investment in structural assets is the continuation of the prioritised programme of inspection and monitoring of all assets. The current programme will be enhanced is two ways:

- additional structured data capture via a revised assessment and data capture methodology, which is designed to provide a consistent approach to the assessment of asset condition and performance
- increased monitoring of asset deterioration where specific defects or issues have been identified

3.5. The results of the survey will categorise each of the structural assets into 3 Structural Grades:

- Structural Grade 1: No Remedial Action Required
- Structural Grade 2: Minor Remedial Action Required
- Structural Grade 3: Remedial Action Required

3.6. Examples of these Structural Grades are provided within each of the individual investment cases.

3.7. It should be noted that Structural Grade 1 is equivalent to NOMs Grade 1, Structural Grade 2 is equivalent to NOMs grades 2 and 3, Structural Grade 3 is equivalent to NOMs Grades 4 and 5.

3.8. The inspection will be annual and where possible undertaken at the same time as the corrosion inspections. The results of the surveys and any other reported defects will be subject to a central Professional Structural / Civils Engineering assessment.

3.9. This risk-based assessment will identify:

- need for visit or investigation
- need for immediate remediation
- need to feed into the prioritisation and delivery methodologies for the individual asset types or sites
- need for ongoing monitoring
- ability to leave until the next inspection

Investment During the Period

3.10. During the investment period, it is proposed to undertake surveys and assessments using the enhanced methodology for all the structural integrity assets. In addition, a full professional technical and risk assessment will be undertaken for all large sites, including inspections of all significant retaining walls, geotechnical slopes and potential structural defects in other assets such as buildings. Where appropriate more in-depth monitoring and surveys will be undertaken.

3.11. The results of this will feed through into the risk-based assessment and remediation of the individual asset classes as described in the remainder of this case. The investment required for the monitoring of each of the assets is included within the specific cases.

Overall Delivery

3.12. The overall approach to delivery for the Structural Integrity assets is to continue to utilise an integrated campaign approach.

3.13. Whole site surveys will be undertaken to assess and understand the condition and performance of the assets. A risk-based decision is taken on the interventions required on the structural integrity assets. These are then integrated with the intervention decisions for the other relevant asset classes and a holistic plan for the site is determined.

3.14. The required interventions are then programmed and delivered in a coordinated manner with other intervention requirements and outage on the NTS etc.

3.15. The above approach will be supplemented with individual remediation's where individual structural integrity defects have been individually identified via other means such as; CM4 inspections, specific civil inspections and monitoring, or other site works. These individual defects will be risk prioritised and the appropriate intervention and delivery timing developed.

Pipe Supports, Pits and Ducting (£39.3m excluding St Fergus Subsidence)

Pipe Supports and Pits

4. Pipe Supports and Pits - Equipment Summary

4.1. This section of the case considers the investment in pipe supports, pits and ducting that provide support and protection to the primary and secondary assets.

4.2. This asset class includes slabs, support plinths, access pits, spring-hangers and pit-wall transitions. Slabs and support plinths provide structural support to the above ground Pipeline. Pipe supports, are generally constructed from concrete or steel, and provide structural support to above ground pipes. Pits allow access to below ground pipework and valves, allowing assets to be accessible for operational reasons, maintenance and inspection. Pits are generally constructed from brickwork or concrete, pit wall transitions, pit covers, some pits are also fitted with water drainage pumps.

4.3. Spring hangers are a specific type of pipe support only installed on compressor sites to support the high-pressure pipeline whilst enabling it to flex due to the stresses driven from the pressure and temperature variations of running compressors. They are designed to provide support to the pipe while allowing it to move, typically in the vertical plane. The design of the constant spring hanger includes a tensioned spring, the forces from which are retained by the integrity of the support body, end plate and retaining rod. Typical forces from the spring in the hanger are of the order of 1½ tonnes.

4.4. The suction and discharge pipework from a compressor has the potential to move due to:

- Vibration from the rotating plant
- Thermal expansion because of the heating of gas in the compression process
- Effect of the change in the gas velocity, particularly on pipe bends
- Surge and other operational envelope occurrences

Pressure Ratings

4.5. The Pipe Supports and Pits assets provide structural support to the Pipelines of the NTS which operate at the full pressure of 70 to 94 bar.

Redundancy

4.6. There is no redundancy in the individual pipe supports. Depending upon the location in the site or network of the pipeline being supported, there may be redundancy in the Pipeline itself.

5. Pipe Supports and Pits - Problem Statement

5.1. The pipe supports and pits were installed at the time of building the site. Over 60% are over 40 years old and subject to severe deterioration. This is leading to their inability to maintain their function of supporting / providing access to the primary asset leading to potential impacts on the integrity of the primary assets. There are examples of where these are assets are causing damage to the primary pipeline assets though either direct contact or promotion of increased corrosion. In some cases, increased loading is applied to the pipeline assets where the undermining of the supports is so extensive that the pipeline is supporting the weight of its own supports.

5.2. Some of the pits are not suitable to provide safe working access to the assets. This is leading to the inability to operate the assets effectively leading to increased costs or outage periods.

Drivers for Investment

5.3. The key drivers for investment in the Pipes Supports and Pits assets are:

- Asset Deterioration
- Ground Movement
- Safety
- Legislation

5.4. Pipe Supports and Pits assets deteriorate over time and with use which leads to their inability to perform their required function. This can also result in them no longer complying with direct legislative requirements.

- Deterioration – the assets are subject to several deterioration mechanisms
- the concrete deteriorates due to age and environmental effects which in turn then exposes reinforcement which further deteriorates and spalls the concrete leading to further deterioration and ultimately structural failure
- the metal parts of the pipe supports and pits are subject to corrosion which can lead to failure or the inability of any moving parts to operate
- corrosion of the pipeline occurs at the pit/wall transition, where the pipeline enters and exits the pit through wall. At this point the coating can deteriorate and as the cathodic protection does not protect the pipeline when out of the ground then this leads to pipeline corrosion.

5.5. Ground Movement – these assets are installed across a number and type of sites, some of which can be subject to ground movement. Despite the foundations installed on construction this can still result in:

- Damage to the support / pit or the associated primary asset
- In some cases, the support can be completely undermined resulting in no support for the primary asset at all
- In extreme cases the undermining can be so severe that the primary asset is supporting the civils structure, causing localised damage or integrity issues

5.6. Safety – corrosion of the metal elements of the spring hanger assets causes them to weaken and fail. These assets contain a large amount of potential energy which when released in an uncontrolled manner during a failure can cause items of metal to be propelled across the site at high speed.

5.7. Legislation – pipe supports are essential to maintaining the integrity of the NTS Pipeline and enabling safe working of the pipeline to comply with PSR.

Impact of No Investment

5.8. Lack of investment in the pipe supports and pits results in their deterioration to the point where they fail to fulfil their purpose and have the potential for impacting the integrity of the Pipeline assets and therefore compliance with obligations under PSR. Furthermore, there is a direct impact on safety and associated asset damage from the failure of some of these assets.

5.9. If the spring hangers were to lose integrity due to corrosion, there is potential for:

- Parts to be ejected because of the release of energy stored in the spring. The design of the constant spring hanger includes a tensioned spring, the forces from which are retained by the integrity of the support body, end plate and retaining rod. Typical forces from the spring in the hanger are of the order of 1½ tonnes.
- Failure of the hanger which provides support to the pipework.

5.10. If the spring hanger becomes inflexible due to corrosion of the spring or pivot mechanism, there is potential for:

- Additional stress on the pipework if the supports constrain pipe movement
- Additional stress of fixed parts in the hanger leading to increased risk of failure

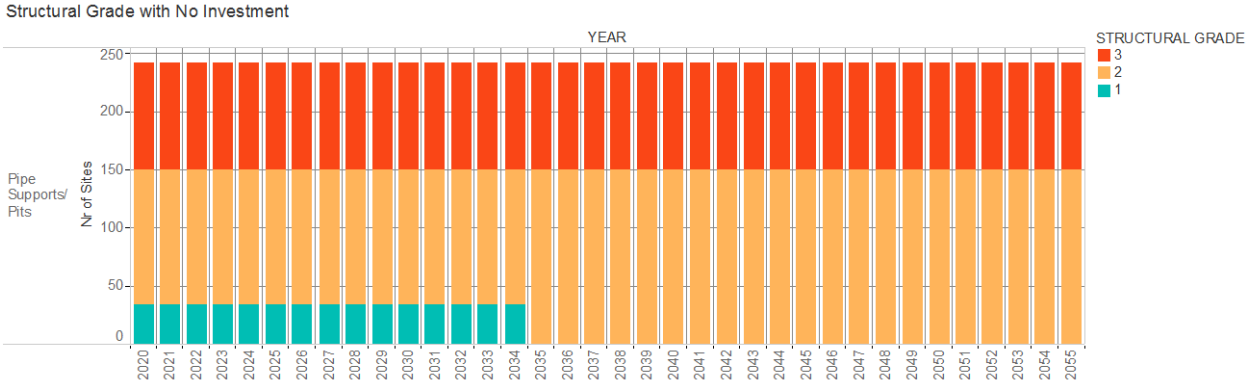
5.11. Some pits require investment to ensure that they can provide a safe working environment to allow the safe operation of the enclosed asset.

5.12. The main impact from the lack of early investment in pipe supports and pits is an increased whole life cost of the asset. Interventions later in the asset life (to remediate significant deterioration) are significantly more expensive than those undertaken early. Signs of concrete deterioration are often visible, in the form of cracks and delamination, but these signs are easily ignored until severe deterioration / spalling occurs, at which point the safety and structural integrity of the asset is prejudiced and the cost of repair dramatically increases.

5.13. Deterioration of the Pipe supports and pits assets has the potential for impacting the integrity of the NTS High Pressure Pipeline assets and therefore compliance with obligations under PSR.

5.14. The chart below shows the count of pipe supports and pits assets by structural integrity inspection grades varying over time given no investment. Around 40% of assets are already assessed as grade 3 in 2018.

Structural Integrity Inspection Grades – No Investment



Desired Outcomes

5.15. The outcome of this investment is to:

- Ensure Pipe Supports and Pits are not a cause affecting the long-term availability, safety and performance of the NTS including the compressors and AGIs.
- Remove the safety risk associated with all the corroded spring hangers
- Undertake the inspection, testing and risk-based remediation to ensure continued legal compliance against all relevant legislation.

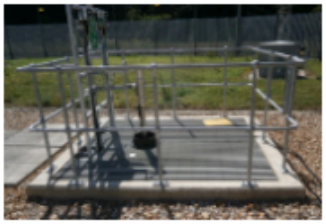
Example of the Problem

5.16. The photographs below show examples and a description for each structural condition grade for the pipe supports and pits assets. These are used for the site inspections and categorisation of the resulting grades. They are fully representative of the issues found on the sites.

Structural Condition Grades for The Pipe Supports

Visual Grade	Description	Examples
❶	**No Risk of Onset of Corrosion**	
No Remedial Action Required	Pipe support plinths, slabs and vent stack support structures are new or in good condition, no evidence of movement, cracking or surface deterioration. Any associated fixings, etc., are new or in good condition.	
❷	**Potential for disruption to service**	
Minor Remedial Action Required	Pipe support plinths, slabs and vent stack support structures are showing signs of deterioration, e.g; corroded fixings, fine cracks, broken concrete fillet around pipe support, signs of water ingress. Arrange minor concrete repairs, replace / re-fix minor areas of damage, identify and where practical seal water damage. More significant deterioration should be recorded as a defect ensuring that all defect numbers are recorded in the report.	
❸	**High Risk of disruption to service**	
Remedial Action Required	Pipe support plinths, slabs and vent stack support structures are significantly deteriorating, e.g; spalling of areas of concrete, evidence of corrosion from reinforcement, loose fixings, open cracks and any evidence of movement such as loss of verticality, etc. Significant or widespread deterioration or evidence of recent movement / change, should be reported immediately to the Senior Engineer (Civils) and recorded as a defect ensuring that all defect numbers are recorded in the report.	

Structural Condition Grades for Pit Assets

No Remedial Action Required	Pits and bunds are new or in good condition, no evidence of movement, cracking or surface deterioration. Any associated drains, seals, etc., are new or in good condition.		
❷	**Potential for disruption to service**		
Minor Remedial Action Required	Pits and bunds structures are showing signs of deterioration, e.g; corroded fixings, fine cracks, minor settlement, signs of water ingress. Arrange minor concrete repairs, replace / re-fix minor areas of damage, identify and where practical seal water damage. More significant deterioration should be recorded as a defect ensuring that all defect numbers are recorded in the report.		
❸	**High Risk of disruption to service**		
Remedial Action Required	Pits and bund type structures are significantly deteriorating, e.g; spalling of areas of concrete, evidence of corrosion from reinforcement, loose fixings, open cracks, leakage, evidence of movement such as loss of verticality, etc. Significant or widespread deterioration or evidence of recent movement or change, should be reported immediately to the Senior Engineer (Civils) and recorded as a defect ensuring that all defect numbers are recorded in the report. N.b. Inspection and reporting of defects in pipe / wall transitions are covered within CM/4 procedure.		

Spring Hangers

5.17. In 2011 a spring hanger at Kirriemuir failed but this was not a total failure of the hanger. The failure was due to fatigue failure of the tension rod followed by a ductile failure. Corrosion of the tension rod was a contributing factor to 9 being replaced in 2011.

5.18. The spring hangers at Chelmsford were severely corroded and had exceeded the manufacturers recommended life expectancy. The spring hanger condition necessitated operational restrictions (Emergency Use only) being placed upon the two compressor units at Chelmsford. This was due to the potential for the several corroded spring hangers to fail. Failure would have generated the following consequences:

- Sudden release of spring tension from the spring hanger mechanism, resulting in a potential projectile.
- Transfer of pipe load onto compressor flanges, potentially resulting in vibration on the machinery unit and resulting in isolation of the units.

5.19. The figure below shows an example of a severely corroded spring hanger.

Corroded Spring Hanger

Spend Boundaries

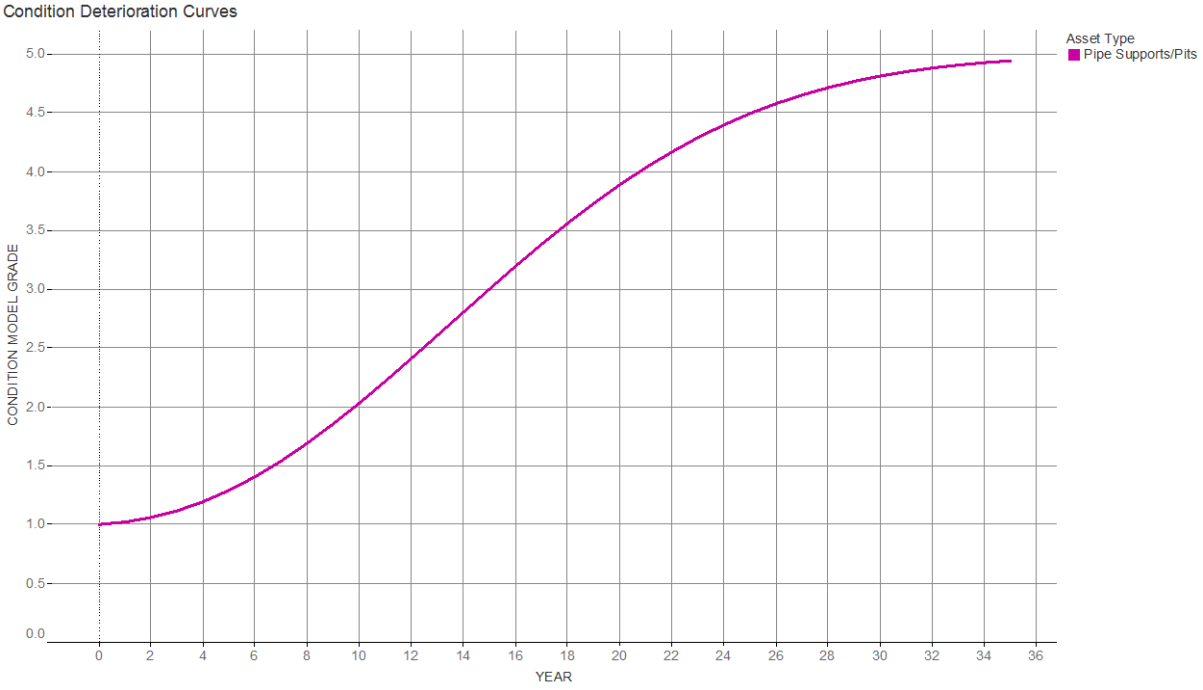
5.20. The proposed investment includes all fixed Pipe Supports and Pits on the NTS, including any 'no-regrets' site investments at both St Fergus and Bacton to keep them safe and operational whilst the separate funding mechanism for the proposed projects are progressed via Uncertainty Mechanisms.

6. Pipe Supports and Pits - Probability of Failure

6.1. The chart below shows the condition deterioration curve for pipe supports/pits structural integrity asset types. The model uses the parameters derived within the development of our NOMS methodology showing how the asset degrades over time from Condition Model Grade 1 to Grade 5. Grade 5 is reached sometime after 35 years from new. Each grade is directly aligned to the asset health definitions used in RIIO-1.

Condition Deterioration Curve

Asset Health Scores	
AH1	New or as new
AH2	Good or serviceable condition
AH3	Deterioration, requires assessment or monitoring
AH4	Material deterioration, intervention requires consideration
AH5	End of serviceable life, intervention required



Probability of Failure

6.2. All Structural Integrity interventions are defined as consequential interventions. This is because the prime function of Structural Integrity assets is to either support or protect enabling a dependent asset/site to perform its primary function of safely and reliably transporting gas. All risk benefits associated with Structural Integrity assets are therefore considered to align with the following definition of a consequential risk intervention:

"Any intervention on a network asset, or other infrastructure asset, that modifies the probability of failure, or consequence of failure of another network asset. A consequential asset can include, for example:

- *installation or removal of physical infrastructure designed to prevent damage to adjacent assets in the event of an asset failure (e.g. installation of a blast wall),*

- *addition or disposal that increases or decreases the resilience of a local or regional network and hence modifies the consequence of failure of other asset(s) in the locality or region."*

Consequential Interventions

6.3. The table below shows the drivers for Structural Integrity asset investment that are defined

Drivers for Structural Integrity Asset Investment

NARMs Asset Intervention Category	Secondary Asset Classes
Consequential Interventions (Non-risk tradeable)	Civil assets - pipe supports and pits

6.4. Our NOMs Methodology attempts to model the indirect benefits delivered by these assets in terms of the reduction in PoF or Consequence of Failure (CoF) upon a related and/or adjacent asset (e.g. the relationship between the pipe support and the pipework it is supporting). These quantified, but indirect, impacts are used within the CBAs accompanying this justification report but are not considered to be reliable enough for use as a NARMs monetised risk metric.

Structural Integrity Interventions

6.5. The table below provides the interventions for the structural integrity assets.

Interventions for Structural Integrity Assets

Interventions	SAC	Intervention Category
A22.03.2.13 / Minor remediation works (Bacton)	Civil assets - pipe supports and pits	Minor Refurbishment
A22.03.2.15 / Monitoring of Structural Integrity Assets (Bacton)	Civil assets - pipe supports and pits	Minor Refurbishment
A22.03.2.17 / Major remediation works (Bacton)	Civil assets - pipe supports and pits	Major Refurbishment
A22.18.1.10 / Relifing of Pipe Supports & Pits at Compressor Sites (Concrete)	Civil assets - pipe supports and pits	Minor Refurbishment
A22.18.1.11 / Relifing of Pipe Supports & Pits at Compressor Sites (Hydro Demolition)	Civil assets - pipe supports and pits	Major Refurbishment
A22.18.1.12 / Relifing of Pipe Supports & Pits at AGIs - Replace Concrete pipe supports	Civil assets - pipe supports and pits	Minor Refurbishment
A22.18.1.13 / Relifing of Pipe supports and pits AGI sites - Inspect, Remove Frame & Cover & Backfill	Civil assets - pipe supports and pits	Minor Refurbishment
A22.18.1.14 / Relifing of Pipe supports and pits AGI sites - Remove Chamber Walls, Inspect & Backfill	Civil assets - pipe supports and pits	Major Refurbishment
A22.18.1.4 / Monitoring of Structural Integrity Assets	Civil assets - pipe supports and pits	Survey
A22.18.1.5 / Minor remediation works	Civil assets - pipe supports and pits	Minor Refurbishment
A22.18.1.6 / Relifing of Pipe Supports & Pits at Compressor Sites (Steel)	Civil assets - pipe supports and pits	Minor Refurbishment
A22.18.1.7 / Relifing of Pipe Supports at AGIs – Replace Steel pipe supports	Civil assets - pipe supports and pits	Major Refurbishment
A22.18.1.8 / Replacement of Pipeline Spring Hangers at Compressor Sites	Civil assets - pipe supports and pits	Replacement

A22.18.1.9 / Mitigation of Settlement	Civil assets - pipe supports and pits	Major Refurbishment

Data Assurance

6.6. All PoF and CoF values are taken from the National Grid Gas Transmission 'Methodology for Network Output Measures' (the Methodology). The Methodology was originally submitted for public consultation in April 2018, with three generally favourable responses received in May 2018. On this basis, Ofgem were happy to provisionally not reject the Methodology pending further work to:

- Produce a detailed Validation Report, confirming the validity of data sources used in the Methodology
- Test a range of supply and demand scenarios and incorporate an appropriate scenario to best represent Availability and Reliability risk

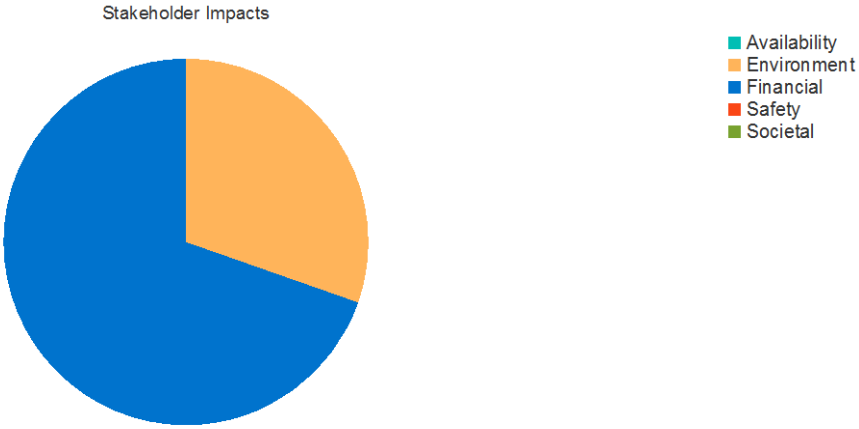
6.7. A review of the Methodology by independent gas transmission experts has been carried out and several improvements identified and incorporated.

6.8. At the time of writing, the final Validation Report has been submitted to Ofgem. We understand that once this work is complete Ofgem will formally "not reject" the Methodology and a License change progressed to restate our RIIO-1 targets in terms of monetised risk commenced.

7. Pipe Supports and Pits - Consequence of Failure

7.1. The pie chart below shows the impacts on outcomes for stakeholders that we expect from failures or defects occurring on pipe supports/pits structural integrity assets. The charts show the relative numbers of consequence events, not relative monetised risk.

Stakeholder Impacts – Pipe Supports/Pits Assets



7.2. Pipe supports ensure that above ground pipework integrity is maintained. The contribution of individual service risk measures towards the overall risk for Pipe Supports and Pits can be explained as follows, in order of significance:

- **Financial risk** is associated with the costs of operating and maintaining the asset at the current level of risk, including routine inspection and maintenance activities. Minor repairs are included but life extending interventions are considered as proactive interventions
- **Environmental risk** is associated with the loss of gas through corrosion at the interface between exposed and buried pipework within the pit

8. Pipe Supports and Pits - Options Considered

Potential Intervention Options

8.1. The following intervention options apply to the Pipe Support and Pits assets:

Mitigation

- **Spring Hangers** – placement of sandbags to mitigate safety impact of asset failure
- **Repair**
- **Supports** - Patch repair any damaged concrete to support slab or plinth and paint where required. Re-fix any loose holding down bolts.
- **Pits** – localised concrete patching, sump pump repair.

Refurbishment

- **Supports** - break-out any cracked concrete and patch repair any damaged concrete to support slab or plinth and fully re-paint where required. Renew fixings and loose holding down bolts.
- **Adjustable steel supports** – fully refurb and repaint and reinstate.
- **Pits** – break-out floor to stable base and re-construct, replacing any drainage / channels as necessary. Repair concrete faces showing deterioration and provide 100% surface protection. Pit-wall transitions seals removed and re-sealed.

Replace

- **Supports** - Saw cut plinth and re-cast onto existing slab if assessed as structurally sound. Break out slab and replace if tilted / settled or concrete is breaking down.
- **Adjustable steel supports** – replace and re-fix / paint as required.
- **Pits -** break-out floor and walls to stable base and re- construct, replacing any drainage / channels as necessary. Install new removable Pit-wall transition seal units to all 'through wall' pipes. Install new access assets / drainage pumps etc., to current standards
- **Spring Hangers** – replacement of entire spring hanger and all the components.

Removal

- **Pits** – remove the pits by either reinstalling all assets above surface or burying to avoid the need for a pit.

Intervention Unit Costs

8.2. The total RIIO-2 investment for Pipe Supports and Pits represents 47% of the Structural Integrity investment theme. The unit costs that support the Pipe Supports have been developed using historical outturn costs obtained for all types of pipe support such as concrete, steel and spring hangers.

8.3. The remaining interventions associated with Pits have been estimated using other methods. Further evidence and justification for these costs is continuing and more

information is expected in terms of supplier quotations for the civils and outturn evidence from PMC for the mechanical aspects of the works.

8.4. The table below provides the unit costs for all the potential Pipe Support and Pits interventions.

Intervention Unit Costs – Pipe Supports and Pits

Intervention	Cost (£)	Unit	Evidence	Data Points	Overall value in BP
Pipe Supports and Pits					
A22.18.1.4 / Monitoring of Structural Integrity Assets	[redacted]	Per asset	Estimated - Other	5	£301,491
A22.18.1.5 / Minor remediation works	[redacted]	Per asset	Estimated - Other	0	£150,799
A22.18.1.10 / Relifing of Pipe Supports & Pits at Compressor Sites (Concrete)	[redacted]	Per asset	Outturn	0	£1,942,147
A22.18.1.11 / Relifing of Pipe Supports & Pits at Compressor Sites (Hydro Demolition)	[redacted]	Per asset	Outturn	2	£11,179,468
A22.18.1.6 / Relifing of Pipe Supports & Pits at Compressor Sites (Steel)	[redacted]	Per asset	Outturn	0	£1,248,261
A22.18.1.12 / Relifing of Pipe Supports & Pits at AGIs - Replace Concrete pipe supports	[redacted]	Per asset	Estimated - Other	0	£7,288,605
A22.18.1.13 / Relifing of Pipe supports and pits AGI sites - Inspect, Remove Frame & Cover & Backfill	[redacted]	Per asset	Estimated - Other	0	£1,984,850
A22.18.1.7 / Relifing of Pipe Supports at AGIs – Replace Steel pipe supports	[redacted]	Per asset	Estimated - Other	0	£4,014,014
A22.18.1.14 / Relifing of Pipe supports and pits AGI sites - Remove Chamber Walls, Inspect & Backfill	[redacted]	Per asset	Estimated - Other	0	£8,275,465
A22.18.1.9 / Mitigation of Settlement	[redacted]	Per site	Estimated - Other	3	£0
A22.18.1.8 / Replacement of Pipeline Spring Hangers at Compressor Sites	[redacted]	Per asset	Outturn	3	£796,787
A22.03.2.13 / Minor remediation works (Bacton)	[redacted]	Per asset	Estimated - Other	0	£36,174
A22.03.2.15 / Monitoring of Structural Integrity Assets (Bacton)	[redacted]	Per asset	Estimated - Other	0	£90,404
A22.03.2.17 / Major remediation works (Bacton)	[redacted]	Per asset	Estimated - Other	0	£66,112

Innovation

8.5. During RIIO-1, we have continued to develop a dynamic portfolio of projects aligned to the Gas Network Innovation Strategy which deliver real value to our customers, stakeholders and the wider industry. We will be continuing to focus on the implementation of innovation into business as usual to drive value throughout everything we do. We will also remain committed to sharing these ideas and best practice across the wider industry to deliver a safe, reliable and efficient network that benefits gas consumers across the UK.

8.6. In the Civils investment theme, we developed and implemented several projects in the RIIO-1 period which will be brought forward into this investment period:

- **Composite Pipe Supports** using a support made from composite materials rather than the traditional steel, yielding a saving of an estimated £500 from reduced maintenance such as painting. As composite materials do not expand at the same rate as steel, the composite support wouldn't be suitable for use in every situation but would yield a benefit where used.
- **Removable Composite Transition Pieces (CTP)** is a project to create a removable piece for pipe to wall transitions, instead of the traditional cementing of the joint, which must be removed and resealed to conduct maintenance and inspections on the pipework in the joint, the CTP will be removable and allow for safer, easier inspection and maintenance. This project is awaiting initial usage, from which an estimated saving and cost will be able to be determinable.

9. Subsidence – St Fergus

Equipment Summary

9.1. St Fergus Terminal comprises a substantial volume of assets including pipework, both above and below ground, over 1200 valves above 4" in diameter, seven gas generator and two electric drive compressors, supported by electrical infrastructure and civil structures to enable safe and reliable operation. The National Grid terminal accepts gas from three sub-terminals (owned by other operators) and processes it before transporting it through five high pressure gas pipelines into the NTS.

9.2. All asset sub themes captured within the Structural Integrity justification report are applicable at St Fergus, including pipe supports, pits & ducting, buildings, security and access, sewage treatment and drainage, tanks and bunds. Most sub themes have become impacted to a certain extent by the localised subsidence experienced at the site.

Problem Statement

9.3. Localised ground movement across St Fergus can and has resulted in damage to civil structures e.g. pipe supports/pits which may impact assets conveying gas. In some cases where ground movement is significant, gas conveying assets have become completely unsupported, or in an extreme case, are providing the structural support, therefore increasing risk of localised damage and/or integrity issues.

9.4. At St Fergus, there is visible evidence of settlement of pipework within the site. This has occurred where there has been no record of post construction works and in areas at, or near to excavations which have taken place over the last few decades. The latter is a largely inevitable, as a result of working in very constricted areas amongst numerous service pipes and ducts, in fine grained material with fluctuating water table which requires constant dewatering.

9.5. Settlement over time will place services including high pressure gas pipework, drainage and the fire-water ring main, under stress that may be beyond their design capability. There are visible examples of localised settlement where excavation and analysis are required to identify potential overstress or conflict with other buried services, which are outside approved service clearance levels. Settlement and subsidence are also presenting trip hazards on site, hence impacting on occupational safety.

Impact of No Investment

9.6. Lack of investment in the subsided areas of the site may lead to the deterioration of pipe supports and pits to the point where they fail to satisfy their primary purpose.

9.7. This may generate pipeline integrity issues where pipelines are no-longer supported, furthermore, there is a direct impact on safety and associated asset damage from the failure of some of these assets.

9.8. Investment is therefore required to ensure subsidence driven pipe support and pit failings do not lead to the loss of containment of high-pressure gas and other safety related issues.

Desired Outcomes

9.9. The outcome of this investment is to:

- Ensure that the long-term availability, safety and performance of the St Fergus site is not adversely impacted by localised subsiding ground.
- Undertake the inspection, testing and risk-based remediation to ensure continued legal compliance against all relevant legislation.

Example of the Problem

9.10. The examples below illustrate the impact of ground movements on the St Fergus terminal and are fully representative of the issues found on site.

Example 1

9.11. The below image is a typical example of an excavation to illustrate the difficulties of working in constricted areas. The 4" actuating gas and 2" instrumentation lines were found to be touching, due to settlement of the ground bed.

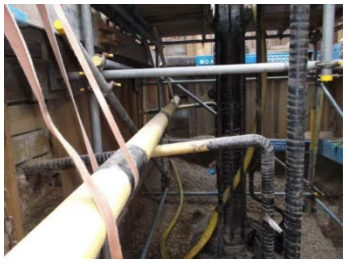
Example 2

9.12. The below image illustrates 100mm subsidence of the pit relative to the adjoining concrete structure. The base of the pit structure had collapsed, bearing down with the entirety of the structure's weight on the high-pressure gas pipe, scouring the pipeline coating and ultimately leading to 57.6% wall loss in the pipeline.

Example 3

9.13. The below image illustrates one of several examples of historic settlement of a pipeline road crossing. This requires excavation and analysis of the pipeline to identify potential overstress or conflict with other services arising due to the settlement. Following any mitigation measures being completed, the pipeline and road will require re-compaction and re-reconstruction. There are 7 of these situations identified to-date.

Examples of ground subsidence impact at St Fergus



Probability of Failure

9.14. Whilst point cloud surveys have been undertaken identifying no substantial site-wide settlement over the last four years (2015 and 2019), we have identified localised issues on site, the scale of impact becoming increasingly visible when excavated.

9.15. For example, in April 2019 settlement of the area around V22013 in pit 35 was subject to investigation (Example 1). Analysis was undertaken on 4" actuating gas pipework and 2" instrumentation lines which were found to be visibly touching inside the excavation. The analysis identified two main areas of concern in relation to overstraining of pipework caused by the subsidence and hence recommended remedial action to stabilise the movement and correct the overstraining of the pipework back to within normal operating limits.

Consequence of Failure

9.16. Buried pipework that is subjected to increased stress caused by ground movements heightens the potential for a loss of containment.

9.17. Lack of proactive investment in areas of subsidence impacts upon the condition and operation of civil structures around the site, resulting in them not fulfilling their primary purpose, potentially impacting the integrity of the gas conveying assets they support, resulting in non-compliance with PSR obligations.

9.18. Increased whole life cost is a critical impact of lack of early preventative investment. Interventions at a later stage in the asset life are more expensive than those undertaken at the early stage.

Options Considered

Potential Intervention Options

9.19. The following intervention options apply to the ground settlement at St Fergus:

Minimum investment - reactive 'fix on fail'.

- Increased reactive remediation of settlement. Minimal monitoring (annual visual inspection) is undertaken as part of maintenance. Therefore, failure is the point at which an issue could be detected.
- Overall safety risk is increased.
- Reactive re-lifing is not a long-term solution. This approach defers expenditure which increases the overall whole life cost of the asset.

Minimum proactive investment.

- Remediating only the worst condition (and known areas) of settlement without consideration for survey and analysis to understand the potential future requirements.
- Results in increased overall safety risk.
- Significant expenditure is still deferred, increasing the whole life cost of the asset and not allowing proactive planning for future regulatory periods.

Proactive, risk-based with reactive provision. (Preferred option)

- A considered and appropriate combination of remediation and some reactive fix on fail as required.
- Maintains the current levels of safety risk.
- Minimal deferral of investment, retaining an acceptable level of risk.

9.20. The preferred option enables the proposed works to be limited to remediation of known, visible areas of the site which have experienced settlement and are vital to the future operation of the site.

9.21. Note that no remedial works have been proposed within parts of the site which solely support Plant 2 (See justification report: A24.16 for further details).

Ducting

10. Ducting - Equipment Summary

10.1. Ducting includes pre-cast and cast in-situ concrete units for the safe routing of communication cables and pipework laid between the instrument house/control room to plant located around the site. Ducts may also be used to house fluid transfer lines e.g. lube oil. Ducting prevents trip hazards and protects the cabling or pipework laid within. Multiple service ducts sometimes meet and are routed into below ground service chambers.

11. Ducting - Problem Statement

11.1. The ducting across were installed alongside the primary assets generally when the NTS sites were built, 63% which are over 40 years old. Ducting is subject to deterioration and the effects of ground movement. This deterioration is causing structural failure of the duct, the lids which results in a significant safety hazard for the NG staff working on site and potential damage to the assets within the ducts. Ground movement is causing movement of the ducting and misalignment of the sections and lids which again present risks to safety and asset integrity.

Drivers for Investment

11.2. The key drivers for investment in the ducting assets are:

- Asset Deterioration
- Legislation

11.3. Ducting deteriorates over time and with use which leads to the inability to perform their required function. This can also result in them no longer complying with direct legislative requirements.

11.4. **Deterioration**

- the concrete ducting elements deteriorate due to age and environmental effects which in turn then exposes any reinforcement which further deteriorates and spalls the concrete leading to further deterioration and ultimately structural failure. This applies to the trench section of the ducting and particularly to the ducting lids which can crack and fail sometimes without any external visual signs when loaded / stood on.
- the ducting is installed in sections which prevents cracking and failure when subject to any ground movement bit can still lead to misalignment of sections and damage to the assets contained within.

11.5. **Legislation** - the integrity of the covers on the ducting assets is essential in NG compliance with H&S in providing a safe working environment.

Impact of No Investment

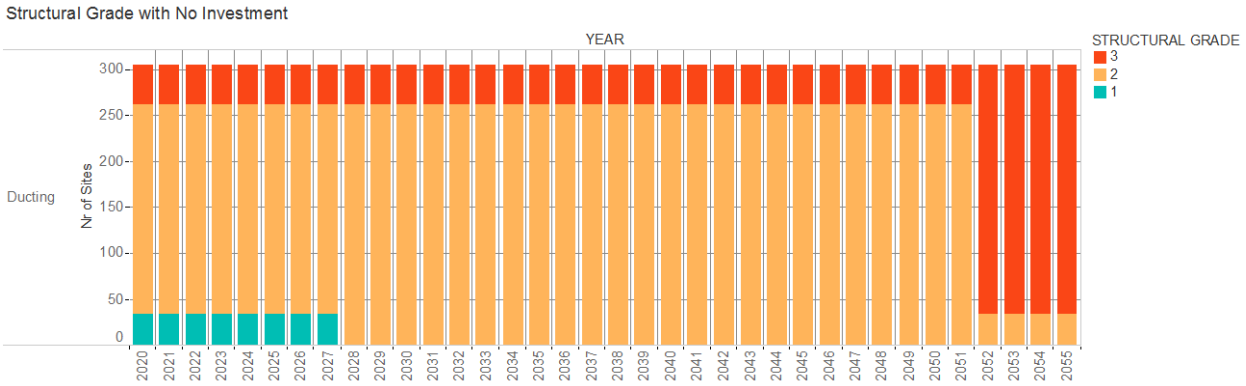
11.6. Lack of investment in ducting leads to deterioration of the duct and its cover which is often not visible without close inspection. The deterioration of the duct can lead to the its failure which presents an unsafe working environment for site users as well as the potential for damage to the cables within the duct. Even small voids or holes can allow access to rats, etc., which can result in chewed / damaged wiring.

11.7. The lids become uneven, unstable and can be structurally unsound. This presents a potential for trips and falls in an operational environment that is required to be safely accessed 24 hours a day, 7 days per week. This risk is further increased during darkness, bad weather and when there is a snow covering.

11.8. Failure of the ducting does not provide adequate protection for the assets within them and in the cases of collapse or significant movement can cause damage to those assets.

11.9. The chart below shows the count of ducting assets by structural integrity inspection grades varying over time given no investment. Around 15% of assets are assessed as structural grade 3 in 2018.

Structural Grade – No Investment



Desired Outcomes

11.10. The outcome of this investment is to:

- Ensure that ducting is not a cause of damage to the operational assets and therefore is not a cause of reduced reliability and availability of the NTS
- Manage the safety risk associated with the deterioration of the ducting on all our sites
- Restore the worst grade to full function and arrest the decline in the grade of the remaining ducting

Example of the Problem

11.11. The photographs below show examples and a description for each structural condition grade for the ducting assets. These are used for the site inspections and categorisation of the resulting grades. They are fully representative of the issues found on the sites.

Structural Conditions – Ducting Assets

Visual Grade	Description	Examples	
1	**No likely risk of disruption to service.**		
No Remedial Action Required	Duct access covers and chambers new or in good condition, no records of broken or damaged ducts. All duct assets are accessible and new or in good condition.		
2	**Potential for damage to cables / hazards to site users.**		
Minor Remedial Action Required	Duct access covers and chambers in serviceable condition, and some records of broken / missing covers or damaged ducts. Arrange minor repairs, replace / re-fix missing covers.		
3	**High risk of damage to cables and/or trip hazards present.**		
Remedial Action Required	Duct access covers and chambers in deteriorated condition, evidence of extensive (>10%) broken, loose or damaged ducts and overfilled ducts. and in poor condition. Raise a defect for issues identified and record all defect numbers in the report.		

Spend Boundaries

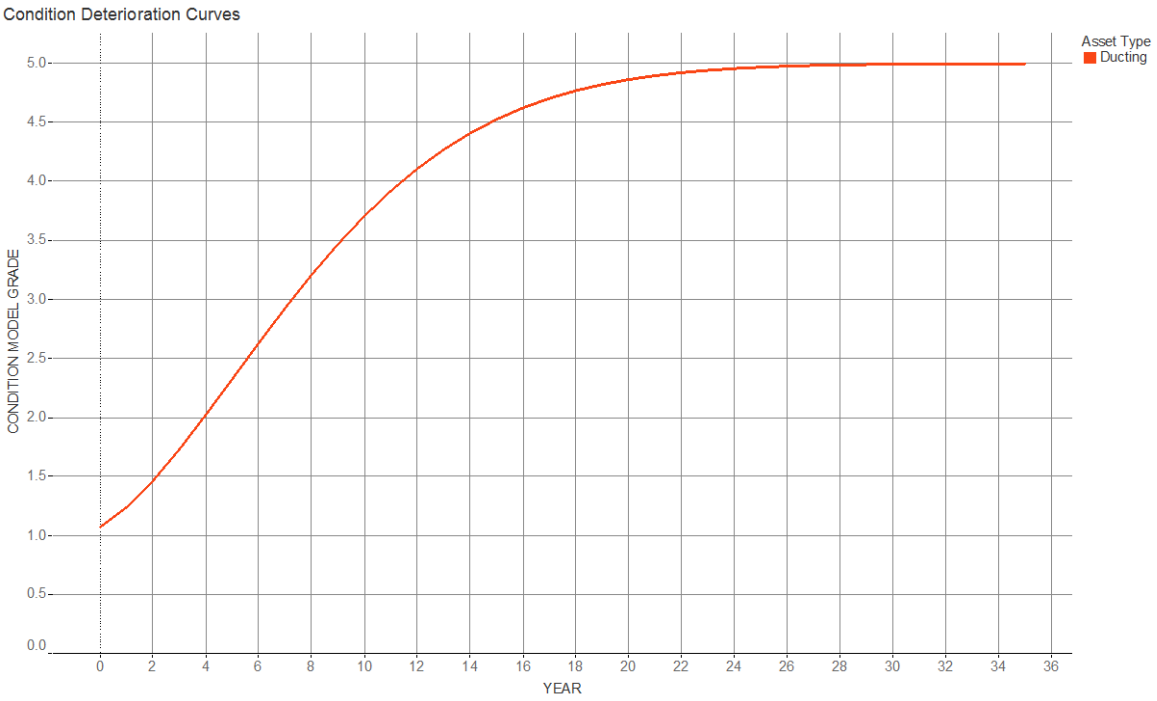
11.12. The proposed investment includes all fixed ducting on the NTS, including any 'no-regrets' site investments at both St Fergus and Bacton to keep them safe and operational whilst the separate funding mechanism for the proposed projects are progressed via Uncertainty Mechanisms.

12. Ducting - Probability of Failure

12.1. The chart below shows the condition deterioration curve for ducting structural integrity asset types. The model uses the parameters derived within the development of our NOMS methodology showing how the asset degrades over time from Condition Model Grade 1 to Grade 5. Grade 5 is reached sometime after 30 years from new. Each grade is directly aligned to the asset health definitions used in RIIO-1.

Condition Deterioration Curve - Ducting

Asset Health Scores	
AH1	New or as new
AH2	Good or serviceable condition
AH3	Deterioration, requires assessment or monitoring
AH4	Material deterioration, intervention requires consideration
AH5	End of serviceable life, intervention required



Probability of Failure

12.2. All Structural Integrity interventions are defined as Consequential Interventions. This is because the prime function of Structural Integrity assets is to either support or protect enabling a dependent asset/site to perform its primary function of safely and reliably transporting gas. All risk benefits associated with Structural Integrity assets are therefore considered to align with the following definition of a Consequential risk intervention:

Any intervention on a network asset, or other infrastructure asset, that modifies the probability of failure, or consequence of failure of another network asset. A consequential asset can include, for example:

- *installation or removal of physical infrastructure designed to prevent damage to adjacent assets in the event of an asset failure (e.g. installation of a blast wall),*

- *addition or disposal that increases or decreases the resilience of a local or regional network and hence modifies the consequence of failure of other asset(s) in the locality or region.*

Consequential Interventions

12.3. The table below shows the drivers for Structural Integrity asset investment that are defined.

Structural Integrity Drivers

NARMs Asset Intervention Category	Secondary Asset Classes
Consequential Interventions (Non-risk tradeable)	Civil Assets - ducting

12.4. Our NOMs Methodology attempts to model the indirect benefits delivered by these assets in terms of the reduction in PoF or Consequence of Failure (CoF) upon a related and/or adjacent asset (e.g. the relationship between the pipe support and the pipework it is supporting). These quantified, but indirect, impacts are used within the CBAs accompanying this justification report, but are not considered to be reliable enough for use as a NARMs monetised risk metric.

Structural Integrity Interventions

12.5. The table below provides the interventions for the structural integrity assets.

Interventions for structural integrity assets

Intervention	SAC	Intervention Category
A22.03.2.10 / Minor remediation works (Bacton)	Civil assets - ducting	Minor Refurbishment
A22.03.2.11 / Monitoring of Structural Integrity Assets (Bacton)	Civil assets - ducting	Minor Refurbishment
A22.03.2.12 / Major remediation works (Bacton)	Civil assets - ducting	Major Refurbishment
A22.18.1.1 / Monitoring of Structural Integrity Assets	Civil assets - ducting	Survey
A22.18.1.2 / Minor remediation works	Civil assets - ducting	Minor Refurbishment
A22.18.1.3 / Relifing of Site Ducting	Civil assets - ducting	Major Refurbishment
A22.22.2.5 / Damaged ducting covers - Replacement (St. Fergus)	Civil assets - ducting	Replacement

Data Assurance

12.6. All PoF and CoF values are taken from the National Grid Gas Transmission 'Methodology for Network Output Measures' (the Methodology). The Methodology was originally submitted for public consultation in April 2018, with three generally favourable responses received in May 2018. On this basis, Ofgem were happy to provisionally not reject the Methodology pending further work to:

- Produce a detailed Validation Report, confirming the validity of data sources used in the Methodology
- Test a range of supply and demand scenarios and incorporate an appropriate scenario to best represent Availability and Reliability risk

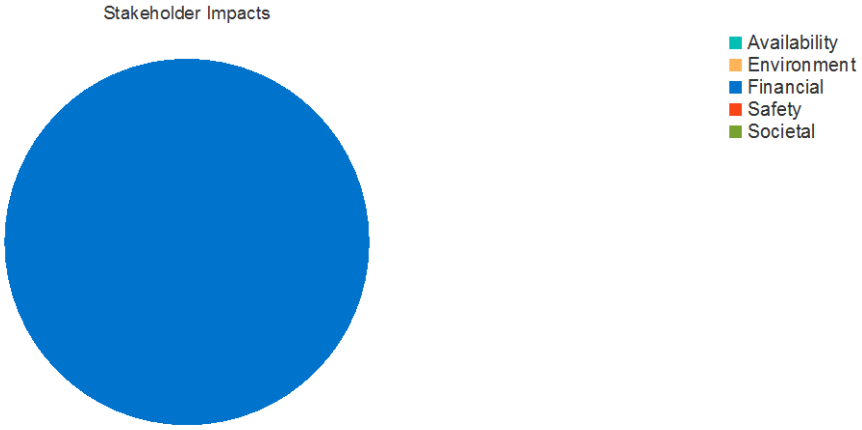
12.7. A review of the Methodology by independent gas transmission experts has been carried out and several improvements identified and incorporated.

12.8. At the time of writing, the final Validation Report has been submitted to Ofgem. We understand that once this work is complete Ofgem will formally “not reject” the Methodology and a License change progressed to restate our RIIO-1 targets in terms of monetised risk commenced.

13. Ducting - Consequence of Failure

13.1. The pie chart below shows the impacts on outcomes for stakeholders that we expect from failures or defects occurring on ducting structural integrity assets. The charts show the relative numbers of consequence events, not relative monetised risk.

Stakeholder Impacts - Ducting



13.2. Ducting assets protect essential services (communications and electrical cables, pipework etc.) required for safe and reliable operation of site assets and the risks carried by these assets are generally indirect (e.g. preventing loss of communications capability which may cause a site outage). Therefore, there is a single service risk consequence attributed to Duct assets:

- **Financial risk** is mostly associated with the costs of operating and maintaining the asset at the current level of risk. Any work extending the life of these assets is considered as proactive maintenance and is not included in the baseline monetised risk value

14. Ducting - Options Considered

Potential Intervention Options

14.1. The following intervention options apply to the ducting assets:

Repair

14.2. Replace any broken sections / lids / jointing chambers, on a like for like basis, where not obsolete

Refurbishment

14.3. Replace all lids and relay any sunk or damaged lengths of duct and jointing chambers

Replace

14.4. Lay new duct to current specifications, transfer any cables and remove redundant ducts, and reinstating the area to suit

Intervention Unit Costs

14.5. The total RIIO-2 investment for Ducting represents 2% of the Structural Integrity investment theme. 72% of unit costs that support the Ducting investment have been based on historical outturn cost data points, which are yet to be verified. The remaining 28% of costs have been developed using other estimation methods. This is due to variability of the scope of activities which could be performed which prevents meaningful quotations being obtained from the supply chain.

14.6. The table below provides the unit costs for all the potential Ducting interventions.

Intervention Unit Costs - Ducting

Intervention	Cost (£)	Unit	Evidence	Data Points	Overall value in BP
Ducting					
A22.18.1.1 / Monitoring of Structural Integrity Assets	[redacted]	Per asset	Estimated - Other	5	£107,261
A22.18.1.2 / Minor remediation works	[redacted]	Per site	Estimated - Other	0	£53,650
A22.18.1.3 / Relifing of Site Ducting	[redacted]	Per site	Outturn	5	£1,383,889
A22.03.2.10 / Minor remediation works (Bacton)	[redacted]	Per site	Estimated - Other	0	£574
A22.03.2.11 / Monitoring of Structural Integrity Assets (Bacton)	[redacted]	Per asset	Estimated - Other	0	£1,435
A22.03.2.12 / Major remediation works (Bacton)	[redacted]	Per site	Estimated - Other	0	£5,101
A22.22.2.5 / Damaged ducting covers – Replacement (St. Fergus)	[redacted]	Per site	Estimated - Other	0	£360,694

Business Case

In this section, we set out our overall investment plan for pipe supports, pits, supporting structures, retaining walls, geotechnical slopes and ducting. This section demonstrates why the proposed investment levels are the right levels to ensure the health and reliability of these assets for the investment period and beyond.

15. Business Case Outline and Discussion

Key Business Case Drivers Description

15.1. The key drivers for investment in the ducting assets are:

- Legislation
- Asset Deterioration

Business Case Summary

15.2. In appraising asset health investment, we have considered how assets can impact on several outcomes:

- Reliability risk
- Environmental risk
- Safety risk
- Impact on wider society

Outcomes Delivered

15.3. The outcome of this investment is to:

- Ensure Pipe Supports and Pits are not a contributing factor impacting upon the long-term availability, safety and performance of the NTS including the compressors and AGIs
- Remove the safety risk associated with corroded spring hangers
- Manage the safety risk associated with the deterioration of the ducting on sites
- Undertake the inspection, monitoring, inspection and risk based remediation to ensure continued compliance against all relevant legislation

Stakeholder Support

15.4. Consumer and stakeholder research and engagement has been integral to the development of our asset health investment plans. Early discussions realised that to engage in meaningful dialogue, our plan outputs should be presented at a programme rather than asset level of detail. This is due to the integrated nature of our Asset Health plan which makes it difficult to disaggregate and engage on individual elements. For details of our stakeholder engagement approach please refer to ‘I want to take gas on and off the system where and when I want’ [Chapter 14 of the GT submission].

16. Programme Options

Programme Option Overview

16.1. Our aim in developing the investment plan is to deliver value to our consumers and stakeholders. Hence, we have considered a range of options from the do nothing position through to reductions in risk across all measures. These have been used to explore the credible options for varying the investment and appraising the impact on our legal compliance, risk position and stakeholders.

16.2. In developing our plan, the following options have been considered for investment in pipe support, pits and ducting assets. Please note that all programme options include any fixed 'no-regrets' investments associated with the Bacton and St Fergus sites.

Baseline – Do Nothing

16.3. The impact of no investment in our Pipe Supports, Pits and Ducts is an increase in service risk over a 10-year period. There is an 80% increase in the number of potential outages, major transportation network closures and gas emission volumes. This is the option against which all the other options are compared.

Programme Option 1 – Fix on Fail

16.4. This option does not include any monitoring of the pipe support, pits and ducting assets and undertakes minimal reactive minor refurbishment to the assets as and when they fail. No proactive replacement is undertaken with only the minimal amount of either minor or major refurbishment work to the function of the asset.

Programme Option 2 – Primary Proactive Re-lifing

16.5. This option considers minimal proactive re-lifing of those assets that have a direct potential impact on the primary assets and/or the safety of staff and members of the public. Only the worst grade assets are fully assessed and considered for re-lifing (refurbishment / replacement) investment. All other assets are fixed on failure / non-compliance with the minimal amount of either minor or major refurbishment work undertaken to restore the function of the asset.

Programme Option 3 – Minimal Proactive Re-lifing

16.6. This option considers minimal proactive re-lifing across all asset types with only the worst condition/performing assets fully assessed and considered for re-lifing investment. All other assets are fixed on failure / non-compliance with the minimal amount of either minor or major refurbishment work undertaken to restore function of the asset.

Programme Option 4 – Risk Based Re-lifing

16.7. This option considers risk based re-lifing of the assets based on their condition, criticality and age. A decision on the level of re-lifing (refurbishment / replacement) is then made. There is some allowance for reactive fix on fail which will consist of the most appropriate minor / major refurbishment or replacement.

Programme Option 5 - Increased Proactive Re-lifing

16.8. This option considers increased proactive re-lifing based on asset condition with all assets considered for replacement at an earlier condition grade. A reduced allowance for fix on fail is included for some assets which deteriorate earlier in their lifecycle.

Programme Options Summary

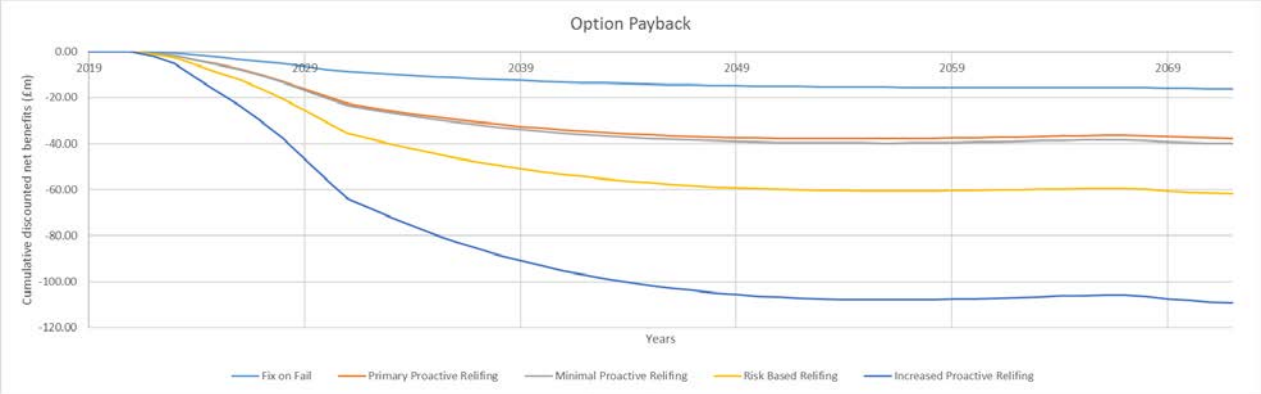
16.9. In considering the CBA for each of the programme options, a summary of all the potential programme options is provided in the table below.

Potential Programme Options

Option	RIIO-2 Invest' £ m	RIIO-3 Invest' £ m	PV Costs £ m	PV benefits £ m	Net NPV £ m	CB Ratio	Payback Period (years)
1 - Fix on Fail	£11.01	£16.02	£21.16	£5.59	£(15.56)	0.26	-
2 - Primary Proactive Re-lifing	£24.00	£49.23	£57.85	£21.47	£(36.38)	0.37	-
3 - Minimal Proactive Re-lifing	£24.78	£51.13	£59.90	£21.56	£(38.34)	0.36	-
4 - Risk Based Re-lifing	£39.29	£73.38	£88.41	£29.01	£(59.41)	0.33	-
5 - Increased Proactive Re-lifing	£75.22	£124.48	£156.16	£50.52	£(105.64)	0.32	-

16.10. The graph shows the cumulative discounted NPV of the net benefit for each of the investment options.

Option Payback– Net NPV



Programme Options Selection

16.11. None of the potential options are cost beneficial over the 45-year analysis period. This is due to limitations in how we model the service risk associated failure of indirect assets (e.g. relationship between the pipe support and the associated pipework). The selection of the preferred option has been based on an assessment of the level of risk, maintaining our compliance with legislation and delivering value for consumers and stakeholders. The outcomes associated with each option are provided below:

Programme Option 1 – Fix on Fail

16.12. This option results in increased reactive re-lifing (i.e. fix on fail) across most of the pipe support, pits and ducting asset types. As little or no monitoring is being undertaken assets are not worked on until they fail or are deemed non-compliant, so may be an effect on the availability of the compressors and other primary assets that impact the service delivered by the NTS. The overall safety risk from structural assets is increased. Reactive re-lifing is not a long-term solution for the assets so this option will defer significant expenditure to after RIIO-2 and RIIO-3 and increase the overall whole life costs of the assets.

Programme Option 2 – Primary Proactive Re-lifing

16.13. Whilst re-lifing some of the worst condition and oldest assets that directly affect other primary assets or safety, this option still results in unacceptable levels of impact on the primary assets and increases in safety risk. Significant expenditure is still deferred outside RIIO-2 and RIIO-3.

Programme Option 3 – Minimal Proactive Re-lifing

16.14. Whilst re-lifing some of the worst condition and oldest assets this option still results in unacceptable levels of impact on the primary assets and increases in safety risk. Significant expenditure is still deferred outside RIIO-2 and RIIO-3.

Programme Option 4 – Risk Based Re-lifing

16.15. A risk based re-lifing of the assets through a considered and appropriate mix of proactive major / minor refurbishment and replacement combined with some reactive fix on fail maintains the levels of safety risk and impact on performance to current levels. There is minimal deferment of expenditure outside the RIIO-2 and RIIO-3 period. This option enables an acceptable level of investment to be maintained across the short and medium terms to manage the level of performance and risk.

Programme Option 5 - Increased Proactive Re-lifing

16.16. Increased proactive replacement and refurbishment reduces the risk of impacting the availability of operational assets and the associated service performance of the NTS. The number of failed assets is minimised however this is at the expense of significantly increased investment in RIIO-2 and RIIO-3. This level of investment is unacceptable to stakeholders and results in an unachievable and unacceptable number of outages on the NTS to enable the work to be undertaken.

Preferred Option

16.17. Our preferred option is Option 4 to maintain the current level of risk through a risk based relifing programme. Some of the other programme options are more cost beneficial through lower levels of investment. These options do not meet the required outcomes of:

- Ensuring pipe supports and pits do not impact the long-term availability, safety and performance of the NTS
- Removing the safety risk associated with corroded spring hangers
- Managing the safety risk associated with the deterioration of the ducting on sites

16.18. The options that are more cost beneficial than Option 4 increase the overall level of risk on the assets. This is not consistent with feedback from our stakeholder engagement who wanted at least the current level of risk maintained.

16.19. Our chosen Option 4 is the only option meets the desired outcomes at the acceptable level of risk at least whole life cost.

16.20. A complete explanation of the selected option is provided in the next section.

17. Decision Approach and Benefits - Pipe Supports and Pits

17.1. In this section, we set out our investment decision approach for pipe supports and pits together with the benefits of the investment.

Key Drivers

17.2. The key drivers for investment in the pipe supports and pits assets are:

- Asset Deterioration
- Ground Movement
- Safety
- Legislation

Investment Decision Approach

17.3. To deliver the outcomes for the investment period the Pipe Support and Pits assets require a mixture of the intervention categories. The decision on the volume mix of each of the interventions required has been determined using the following approach.

17.4. For Pipe Supports, Pits, Plinths, Slabs, Retaining Walls and Slopes:

- There will be an annual inspection of all pipe supports and pits with the associated monitoring, assessment and intervention
- The predicted volumes of investment for in the period are based on an analysis of historical investment combined with the knowledge from the RIIO-1 inspections. All results from RIIO-1 have been analysed and categorised – Grade 1 (no action), Grade 2 (repair, refurbish), Grade 3 (replace)
- By the end of RIIO-3 – 40% of pipe supports and pits assets will have received the investment required to return the assets to, or maintain them within a structural Grade 2
- By the end of RIIO-3 all significant supporting structural assets such as retaining walls and geotechnical slopes will have been inspected and where necessary a monitoring regime established

17.5. For Spring Hangers:

- For spring hangers, there is a fully proactive replacement programme proposed for all sites. This includes 8 at Chelmsford and the remaining 47 at other compressor sites. The decision to replace these assets is based on the information gathered during RIIO-1 together, with a full risk assessment of each based on its probability and impact of failure
- The delivery of spring hangers will be undertaken on a compressor unit basis prioritised based on asset risk combined with outage availability

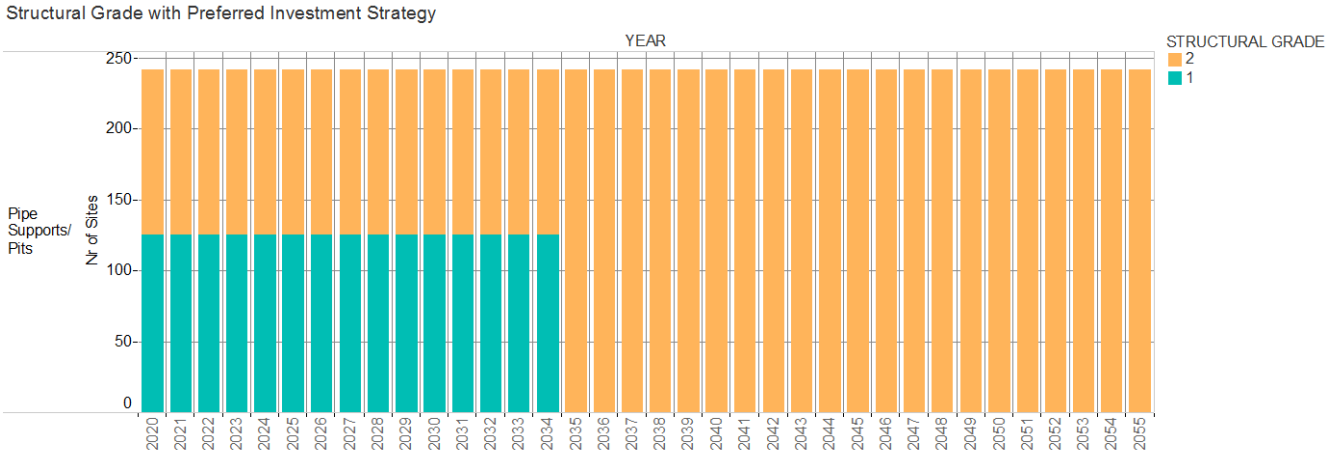
17.6. The proposed mix of interventions and programme of work will be continually reassessed and reprioritised based on the ongoing inspection and monitoring programme including other defects or plant status issues that are identified.

Benefits of Investment

17.7. The investment will achieve the following improvements in the Pipe Supports and Pits Assets.

17.8. The chart below shows the count of pipe supports and pits assets by structural integrity inspection grades varying over time assuming the preferred investment option is applied. This shows that with the preferred investment option, the structural grade 3 assets are returned to grade 1 and even with ongoing deterioration, the assets remain at grade 1 or 2.

Structural Grade with Preferred Investment Strategy



18. Decision Approach and Benefits - Ducting

18.1. In this section, we set out our investment decision approach for ducting together with the benefits of the investment.

Key Drivers

18.2. The key drivers for investment in the ducting assets are:

- Legislation
- Safety
- Asset Deterioration

Investment Decision Approach

18.3. The investment proposed is to move to a proactive risk-based inspection, monitoring and intervention regime to manage the ducting assets. By the end of RIIO-3 the 80% of sites with the highest risk ducting assets will have proactive remediation work in the investment period. The remaining sites will be subject to a reactive approach driven by the reporting of specific issues. The level of intervention has been based on historical data.

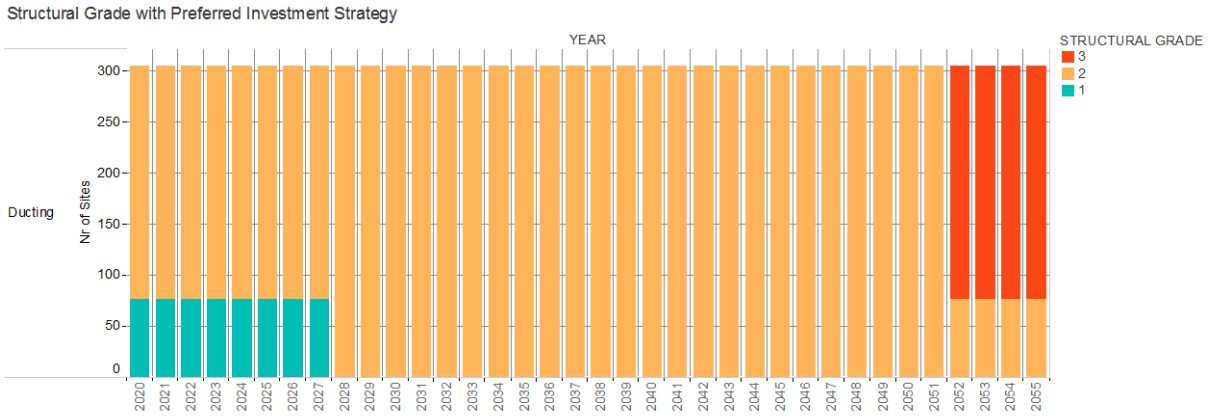
18.4. The proposed mix of interventions and programme of work will be continually reassessed and reprioritised based on the ongoing inspection and monitoring programme including other defects or plant status issues that are identified.

Benefits of the Investment

18.5. The investment will achieve the following improvements in the ducting assets.

18.6. The chart below shows the count of ducting assets by structural integrity inspection grades varying over time assuming the preferred investment option is applied. This shows that with the preferred investment option, the structural grade 3 assets are returned to grade 1 and even with ongoing deterioration, the assets remain at grade 1 or 2 until 2051.

Structural Grade with Preferred Investment Strategy



19. Business Case Summary

19.1. In this section we set out our overall investment plan for pipe support, pits and ducting.

Preferred option

[redacted] To deliver the required outcomes for all stakeholders, we have developed the most effective combination of efficient interventions. These form the programme of work for the pipe support, pits and ducting assets in the investment period. [redacted]

Intervention Volumes

[redacted]

Asset Health Spend Profile

19.3. The profile of investment in the pipe support, pits and ducting assets, driven from the derived volumes of work and the efficient unit costs, for the period is shown is the table below:

Investment Profile

Investment (£ 000's)	RIIO-2					RIIO-3				
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Civil assets - ducting	33	34	86	881	879	879	879	879	879	776
Civil assets - pipe supports and pits	3,865	5,122	11,336	9,559	7,493	13,034	13,169	15,800	14,555	12,528

Total	3,897	5,156	11,422	10,439	8,373	13,913	14,048	16,679	15,433	13,303
	39,287					**73,376**				

Intervention Drivers

19.4. The following chart shows the breakdown of investment across each of the intervention drivers. This shows that all of the investment consists of interventions that are driven by internal policy.

RIIO-2 Pipe Supports, Pits and Ducting Intervention Drivers[2]

Programme CBA

19.5. We are targeting an appropriate level of asset health investment to mitigate the reliability, safety and environmental risks from an ageing asset base.

19.6. In line with HM Treasury Green Book advice and Ofgem guidance we have appraised whether investment in the pipe support, pits and ducting assets is value for money. We have considered costs over a 45-year period in a full cost benefit analysis (CBA).

19.7. The CBA shows that investment in these assets is not cost beneficial over the 45-year period. This is due to limitations in how we model the service risk associated failure of indirect assets (e.g. relationship between the ducting and associated electrical/data cables). This is shown below.

Cost Benefit Analysis[3]

	10 years	20 years	30 years	45 years
Present Value costs (£m)	£37.56	£60.96	£75.50	£88.41
Present Value H&S benefits (£m)	£0.00	£0.00	£0.00	£0.00
Present Value non--H&S benefits (£m)	£2.18	£7.62	£15.59	£29.00
Net Present Value (£m)	£(35.38)	£(53.34)	£(59.91)	£(59.41)

[2] See Appendix A for intervention driver category definitions

[3] A14.19.1 Pipe Supports, Pits and Ducting CBA

19.8. We have challenged whether this is the right programme of work. There are no acceptable options for investment in the pipe supports, pits and ducting that are cost beneficial. However, the investment in these assets is essential to the safe operation of the NTS. Pipe supports carry the primary pipeline assets and their continued performance is essential to maintaining its integrity. Pits provide safe access to below ground elements of plant and equipment. The entry and exit of the assets into the pit are a source of corrosion and this risk needs to be managed. Ducting effectively protects the assets that run within it whilst enabling easy access but their deterioration can cause damage to those assets and safety risks for those working on an operational site 24 hours a day.

19.9. Our inspection, monitoring and condition assessment approach with early intervention is widely accepted as the lowest whole life cost of managing these long-life assets. In developing the proposed programme of work, we aimed to achieve the optimal balance between the level of investment and the risk to outcomes. We believe we have achieved this through a programme of re-lifing a proportion of the assets on a site by site basis whilst managing any individual defects on other sites on a case by case basis.

19.10. This approach achieves the balance of ensuring the assets remain fit for purpose in the medium term whilst maintaining affordable and deliverable levels of investment in the short term.

19.11. We have used the potential range of unit cost variance to assess the sensitivity of the Cost Benefit Analysis to the upper and lower limits. The graph below shows the results of this compared to the preferred option.

Net Benefits of Upper and Lower Unit Cost Sensitivity

19.12. Whilst the level of cost benefit as the unit costs vary, the investment remains non-cost beneficial across the range of unit costs, this does not cause our decision to change.

19.13. This level of investment will ensure we successfully manage asset deterioration and obsolescence, whilst meeting our legal obligations. It will ensure we deliver the outcomes that consumers and stakeholder tell us they want us to meet.

Preferred Option

20. Preferred Option Scope – Pipework, Cladding and Cathodic Protection

20.1. The section summarises our preferred investment plan required to deliver acceptable and affordable outcomes for our stakeholders.

Preferred option

20.2. To deliver the required outcomes for all stakeholders, we have developed the most effective combination of efficient interventions. These form the programme of work for the pipe support, pits and ducting assets in the investment period. [redacted]

Intervention Volumes

[redacted]		
[redacted]		
[redacted]		
[redacted]		
[redacted]		
[redacted]		
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[redacted]		

20.3. The profile of investment in the pipe support, pits and ducting assets, driven from the derived volumes of work and the efficient unit costs, for the period is shown is the table below:

Investment Profile

Investment (£ 000's)	RIIO-2					RIIO-3				
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Civil assets - ducting	33	34	86	881	879	879	879	879	879	776
Civil assets - pipe supports and pits	3,865	5,122	11,336	9,559	7,493	13,034	13,169	15,800	14,555	12,528
Total	3,897	5,156	11,422	10,439	8,373	13,913	14,048	16,679	15,433	13,303
	39,287					**73,376**				

Delivery Planning

20.4. At this point in time the delivery of our RIIO-2 and RIIO-3 plans are in principle deliverable based on initial assessments of work. We will regularly review the plan to consider any known or changing constraints, customer impacts and bundling opportunities. In the event of churn our plan must be reoptimized to reflect the impact of the change and provide an opportunity to reconsider the efficient timing of delivery.

20.5. Outages and pressure reductions may be necessary when intervening on these assets to ensure safety and system integrity, however this may not be necessary in every case and will also depend on the immediate environment being suitable for construction access. When required the availability of outages and pressure reductions are extremely limited across most of the NTS due to the radial nature of the network. It is therefore most efficient from both financial and network risk points of view to bundle investment across asset classes within the same outage period and this may involve taking an outage on a large section of the network and working on multiple assets and sites simultaneously. To achieve, this the assets need to be isolated, vented, repaired/replaced and then returned to service for the duration of their technical lives without further intervention. The cost of recompression for a large section of the network once the work is complete could be up to £0.25m, plus the environmental costs associated with the venting of gas for the isolation. A systematic approach therefore maximises the work undertaken in any outage whilst ensuring efficient delivery through minimised project overheads.

20.6. This approach is particularly effective when applied at a feeder level or for a whole site. In which case the preparatory inspection, investigation, risk assessment, planning and procurement activities can be completed as far as possible before the outage. This allows the maximum amount of intervention and risk reduction to be bundled into a single 'campaign' across the length of the feeder. During RIIO-1 this has proved to be an extremely efficient and effective approach to delivery of our programmes of work.

20.7. We recognise that whilst this is in many cases the most efficient method of delivery there are still individual or groups of assets that present a risk to our performance that do not 'fit' into the planned 'campaign' approach. We will ensure that these risks are

remediated as efficiently as possible through individual or small groups of targeted interventions.

20.8. Where asset interventions do not require outages then the campaign approach will still be applied to maximise the opportunity for delivery of the same type of work across many locations. This enables efficient procurement through significant volumes of common works.

Buildings, Security and Access (£33.7m)

Security and Fencing

21. Security and Fencing - Equipment Summary

21.1. This section of the case considers the investment in security, fencing, building and access that prevent third party damage, access to and a safe operational and working environment for our primary and secondary assets.

21.2. Security protects our assets from breaches by external parties. Fences and gates are provided to minimise opportunities for unauthorised entry or damage to National Grid assets. The selection of fence and gate type is commensurate with the degree of security protection required.

21.3. Fences used at operational sites can range from simple wooden post and rail type fences to protect assets from livestock to metal weld-mesh type fences and electrified Integrated Security Solutions (ISS) fences. Gates provide pedestrian and vehicle access and may be manually or electrically operated. Fences and gates may be installed in conjunction with a range of other ISS security features such as CCTV to provide a high level of security.

21.4. The most critical sites have a full integrated security system (ISS), mostly installed during RIIO-1, to meet the requirements of the Critical National Infrastructure Assessment. The investment required to maintain ISS IT Hardware & Technical asset is included in GT5a Theme Paper. The structural elements of the recently installed ISS security do not require investment in the period.

21.5. The assets include fencing, gates, associated control systems and some small amounts of CCTV, electric gates and electrification of some of the fences.

Redundancy

21.6. There is no redundancy of the security and fencing assets on any site.

22. Security and Fencing - Problem Statement

22.1. The security and fencing assets historically have a design standard across the NTS that is a welded hollow section steel fence post and chain-link fence. The design life of these assets is 20 to 30 years. Many of these assets are now over 30 years old and subject to extensive corrosion. Some sites have fencing that are corroded to such an extent that they do not provide effective security against third party entry. The mechanical /electrical elements of the security systems such as electric gates have similar design lives and are subject to significant wear with the number of defects increasing. Electronic elements such as CCTV and control systems are of similar age and suffering increased defects and failures.

22.2. The fencing at Wisbech compressor station has severe corrosion to both the posts and chain link fence to a point where its structural integrity is compromised. The control and drive systems for the gates are at end of life.

Drivers for Investment

22.3. The key drivers for investment in the Security assets are:

- Asset Deterioration
- Changing Standards
- Legislation

22.4. Security assets deteriorate over time and with use which leads to their inability to perform their required function. This can also result in them no longer complying with direct legislative requirements.

22.5. Deterioration – the security and fencing assets are subject to several deterioration mechanisms

- corrosion of the fencing and gates including the support posts
- wear of associated moving parts such as gearboxes, motors etc.
- electronic component deterioration leading to end of life for electronic control systems and a small amount of CCTV

22.6. Legislation – the assets are essential in maintaining compliance with H&S legislation in keeping members of the public safe from injury

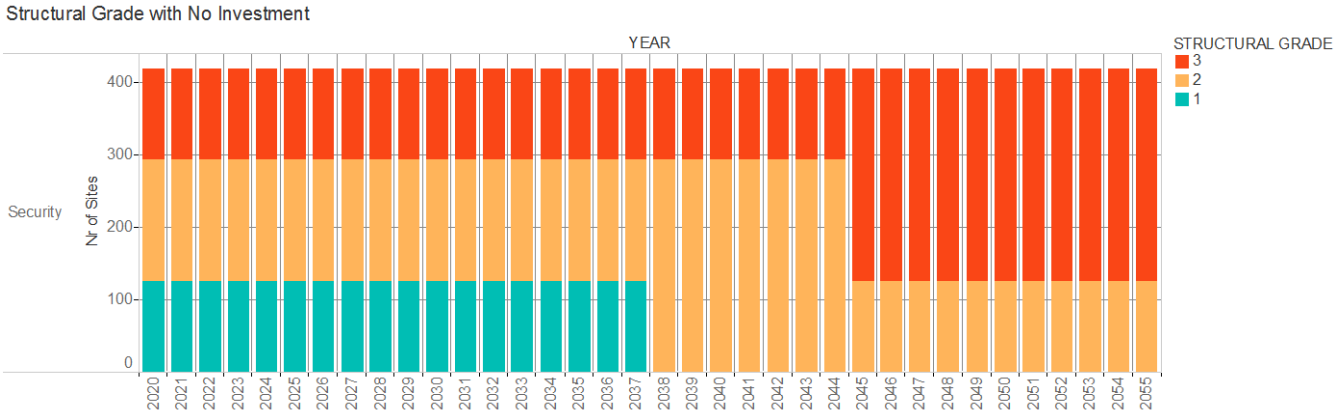
22.7. Changing Standards – a small number of sites may change security requirements during the investment period, which may drive a change of fencing. This is not anticipated to be a driver of a large amount of investment. The security requirements for a site will only be reviewed if there is specific evidence of a change in circumstance otherwise no change will be required.

Impact of No Investment

22.8. Lack of investment in the Security assets will allow them to continue to deteriorate and increase the number of failures found on inspection. This will potentially lead to unauthorised access to the sites on the NTS with potential non-compliance with the H&S legal obligations to protect the public. The operation of the NTS could be compromised should a security breach lead to tampering with the assets.

22.9. The chart below shows the count of security assets by structural integrity inspection grades varying over time given no investment. Around 30% of assets are assessed as grade 3 in 2018 with nearly 40% assessed as grade 2.

Structural Grade – No investment



Desired Outcomes

22.10. The outcome of this investment is to:

- Ensure the security on the highest risk (Non-ISS sites) is maintained to a level where the risk of third-party intrusion is managed and the effect on the operation of the assets is minimised.

Example of the Problem

22.11. The photographs below show examples and a description for each structural condition grade for the security assets. These are used for the site inspections and categorisation of the resulting grades. They are fully representative of the issues found on the sites.

Structural Condition Grades for Security Assets

Visual Grade	Description	Examples
❶	**No Risk of disruption to site security**	 
No Remedial Action Required	Security fencing and vehicular & pedestrian gate structures are new or in good condition, no evidence of movement, cracking, surface deterioration or corrosion. Any associated fixings, etc., are new or in good condition.	
❷	**Potential for disruption to site security**	 
Minor Remedial Action Required	Security fencing and vehicular & pedestrian gate structures are showing signs of deterioration, e.g; fence post coatings flaking, signs of corrosion to fixings and fence posts, cracks in concrete cills but not affecting the fence stability. Arrange minor concrete repairs, replace / re-fix minor areas of damage, flaking coatings. More significant / extensive deterioration should be recorded as a defect ensuring that all defect numbers are recorded in the report.	
❸	**High Risk of loss of security or hazard to public or site users.**	 
Remedial Action Required	Security fencing and vehicular & pedestrian gate structures are significantly deteriorating, e.g; severe corrosion of fence or strainer posts, open cracks in concrete cills affecting the fence stability. Evidence of movement such as loss of verticality, etc. Significant or widespread deterioration or evidence of recent movement / change, should be reported immediately to the Senior Engineer (Civils) and recorded as a defect ensuring that all defect numbers are recorded in the report.	

Wisbech Compressor Station

22.12. The twin chain link (inner and outer) electrified fence at Wisbech currently has severe internal corrosion to the sectional square posts. Areas of the chain link are corroded away within the plastic coating. Both are resulting in loss of structural integrity of the fence.

22.13. The photographs below illustrate the corrosion issues with the fence.



Wisbech Compressor Station

22.14. The electric gate, control system and mechanical drive is at the end of life.

Spend Boundaries

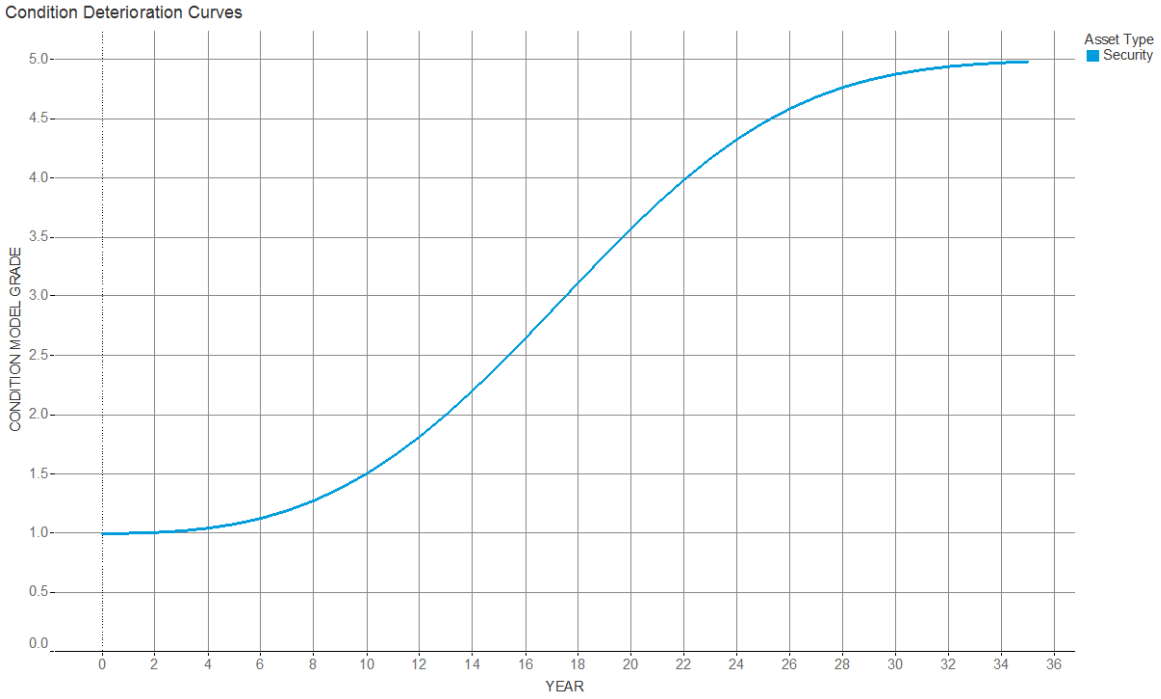
22.15. The proposed investment includes all fixed Security assets on the NTS, including any 'no-regrets' site investments at both St Fergus and Bacton to keep them safe and operational whilst the separate funding mechanism for the proposed projects are progressed via Uncertainty Mechanisms.

23. Security and Fencing - Probability of Failure

23.1. The chart below shows the condition deterioration curve for security structural integrity assets. The model uses the parameters derived within the development of our NOMS methodology showing how the asset degrades over time from Condition Model Grade 1 to Grade 5. Grade 5 is reached sometime after 35 years from new. Each grade is directly aligned to the asset health definitions used in RIIO-1.

Condition Deterioration Curve

Asset Health Scores	
AH1	New or as new
AH2	Good or serviceable condition
AH3	Deterioration, requires assessment or monitoring
AH4	Material deterioration, intervention requires consideration
AH5	End of serviceable life, intervention required



Probability of Failure

23.2. All Structural Integrity interventions are defined as consequential interventions. This is because the prime function of Structural Integrity assets is to either support or protect enabling a dependent asset/site to perform its primary function of safely and reliably transporting gas. All risk benefits associated with Structural Integrity assets are therefore considered to align with the following definition of a consequential risk intervention:

*"Any intervention on a network asset, or other infrastructure asset, that modifies the probability of failure, or consequence of failure of **another network asset**. A consequential asset can include, for example:*

- *installation or removal of physical infrastructure designed to prevent damage to adjacent assets in the event of an asset failure (e.g. installation of a blast wall),*
- *addition or disposal that increases or decreases the resilience of a local or regional network and hence modifies the consequence of failure of other asset(s) in the locality or region."*

Consequential Interventions

23.3. The table below shows the drivers for Structural Integrity asset investment that are defined

Drivers for Investment

NARMs Asset Intervention Category	Secondary Asset Classes
Consequential Interventions (Non-risk tradeable)	Security

23.4. Our NOMs Methodology attempts to model the indirect benefits delivered by these assets in terms of the reduction in PoF or Consequence of Failure (CoF) upon a related and/or adjacent asset (e.g. the relationship between the pipe support and the pipework it is supporting). These quantified, but indirect, impacts are used within the CBAs accompanying this justification report but are not considered to be reliable enough for use as a NARMs monetised risk metric.

Structural Integrity Interventions

23.5. The table below provides the interventions for the structural integrity assets.

Interventions

Option Name	SAC	Intervention Category
A22.18.2.10 / Minor remediation works	Security	Minor Refurbishment
A22.18.2.11 / Security - Fences and Gates - AGI (Minor Works)	Security	Minor Refurbishment
A22.18.2.12 / Security - Fences and Gates - Compressor	Security	Replacement
A22.18.2.9 / Monitoring of Structural Integrity Assets	Security	Survey
A22.22.2.7 / ISS software, cameras and monitors - Replacement (St. Fergus)	Security	Replacement

Data Assurance

23.6. All PoF and CoF values are taken from the National Grid Gas Transmission 'Methodology for Network Output Measures' (the Methodology). The Methodology was originally submitted for public consultation in April 2018, with three generally favourable responses received in May 2018. On this basis, Ofgem were happy to provisionally not reject the Methodology pending further work to:

- Produce a detailed Validation Report, confirming the validity of data sources used in the Methodology
- Test a range of supply and demand scenarios and incorporate an appropriate scenario to best represent Availability and Reliability risk

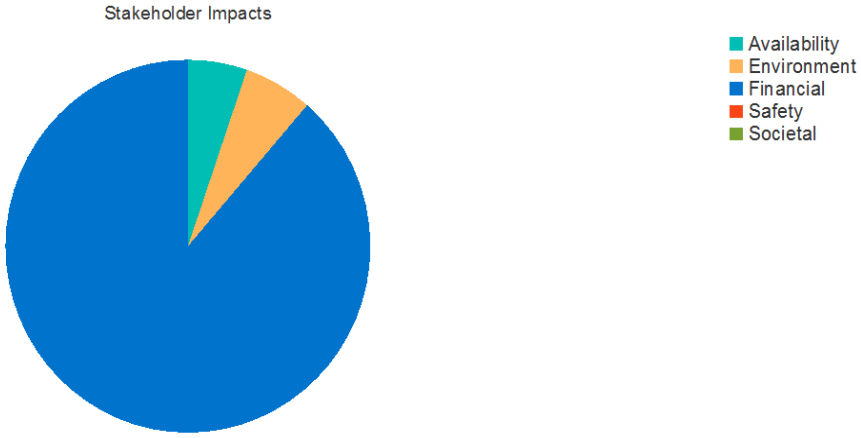
23.7. A review of the Methodology by independent gas transmission experts has been carried out and several improvements identified and incorporated.

23.8. At the time of writing, the final Validation Report has been submitted to Ofgem. We understand that once this work is complete Ofgem will formally “not reject” the Methodology and a License change progressed to restate our RIIO-1 targets in terms of monetised risk commenced.

24. Security and Fencing - Consequence of Failure

24.1. The pie chart below shows the impacts on outcomes for stakeholders that we expect from failures or defects occurring on security integrity assets. The charts show the relative numbers of consequence events, not relative monetised risk.

Stakeholder Impacts – Security and Fencing



24.2. Site security is essential to protect NTS assets through accidental or wilful damage by 3rd parties. The likelihood of a security event and subsequent third-party damage is indirectly related to the condition of the security assets. The contribution of individual service risk measures towards the overall risk for Security assets, is listed in order of significance:

- **Financial risk** is mostly associated with the costs of operating and maintaining the assets at the current level of risk. Clean-up and prosecutions costs are considered as Environment risk
- **Environmental risk** is associated with the emissions associated with maintaining security assets and the direct impact of any third-party damages on the loss of gas from leaks/ruptures
- **Availability risk** is associated with the potential outages associated with the loss of an asset due to third-party damage, causing an asset outage
- **Societal risk** is associated with environmental impacts of off-site spills

25. Security and Fencing - Options Considered

Potential Intervention Options

25.1. The following intervention categories apply to the Security assets:

Repair

- Replace broken fence posts / rails, sections of chain-link panels / palisades, localised repairs to concrete sill cracks. Repair motors / gearboxes / bearings or control systems to electric gates. Patch painting to surface corrosion.

Refurbishment

- Replace chain-link and any individual fence / gate posts which have failed. Replace all moving parts and control system to electric gate opening systems. Replace CCTV cameras and associated monitoring / recording systems. Refurbish any electric fence system.

Replacement

- On a like for like basis. Remove existing security fence and provide temporary security. Construct new fence and gate arrangement - timber / weldmesh / palisade, in accordance with specifications. Install new control and security systems / electric gates etc., to suit site security risk assessment.

Intervention Unit Costs

25.2. The total RIIO-2 investment for Security and Fencing represents 25% of the Structural Integrity investment theme. A large proportion of the unit costs that support the Security and Fencing investment have been developed using historical outturn cost data points (94%). The remainder (6%), due to the unavailability of outturn cost data and the broad spectrum of activities that can be performed, have been developed by other estimation methods.

25.3. The table below provides the unit costs for all the potential security interventions.

Intervention Unit Costs – Security & Fencing

Intervention	Cost (£)	Unit	Evidence	Data Points	Overall value in BP
Security & Fencing					
A22.18.2.9 / Monitoring of Structural Integrity Assets	[redacted]	Per asset	Estimated - Other	5	£798,455
A22.18.2.10 / Minor remediation works	[redacted]	Per asset	Estimated - Other	0	£399,369
A22.18.2.11 / Security - Fences and Gates - AGI (Minor Works)	[redacted]	Per asset	Outturn	10	£14,256,951
A22.18.2.12 / Security - Fences and Gates - Compressor	[redacted]	Per asset	Outturn	2	£4,376,842
A22.22.2.7 / ISS software, cameras and monitors – Replacement (St. Fergus)	[redacted]	Per site	Estimated - Other	0	£0

Buildings and Enclosures

26. Buildings and Enclosures - Equipment Summary

26.1. Buildings and enclosures include most associated buildings and man-entry sized kiosks. The assets range from instrumentation rooms and workshops, through large enclosures protecting significant plant down to smaller kiosks for quality and control assets. They consist of brick structures, small glass-reinforced plastic (GRP) kiosks, huts and cabinets housing instrumentation, and process equipment.

26.2. The purpose of the buildings and enclosures is to protect vulnerable plant and equipment from damage and weathering, and create a safe and suitable workspace for maintenance, storage and repair operations, staff offices, control rooms and related facilities. Some housings are designed primarily to provide acoustic protection for site neighbours such as nearby residential properties.

27. Buildings and Enclosures - Problem Statement

27.1. The building and enclosure assets were installed when the NTS sites were built. A number of the buildings and enclosures and many are over 40 years old. They are subject to deterioration and require investment to ensure that they maintain their ability to protect the assets that they contain and provide a safe working environment for NG staff.

Drivers for Investment

27.2. The key drivers for investment in the building assets are:

- Asset Deterioration
- Legislation

27.3. Buildings deteriorate over time and with use which leads to their inability to perform their required function. This can also result in them no longer complying with direct legislative requirements.

27.4. Deterioration – elements of the assets which are typically subject to deterioration:

- many of the structures have a flat roof for which the membrane deteriorates over time and with environmental exposure
- wooden elements of the building such as door frames or windows which rot over time
- NG have many GRP kiosks which are subject to breakdown of the structural and covering materials due to environmental exposure. The seals around doors and hatches degrade over time and fail to seal effectively against water ingress.

27.5. Legislation – the integrity of the buildings is essential in NG compliance with H&S in providing a safe working environment

27.6. Asbestos – some the buildings and enclosures contain asbestos which requires effective management during works to ensure compliance with H&S legislation.

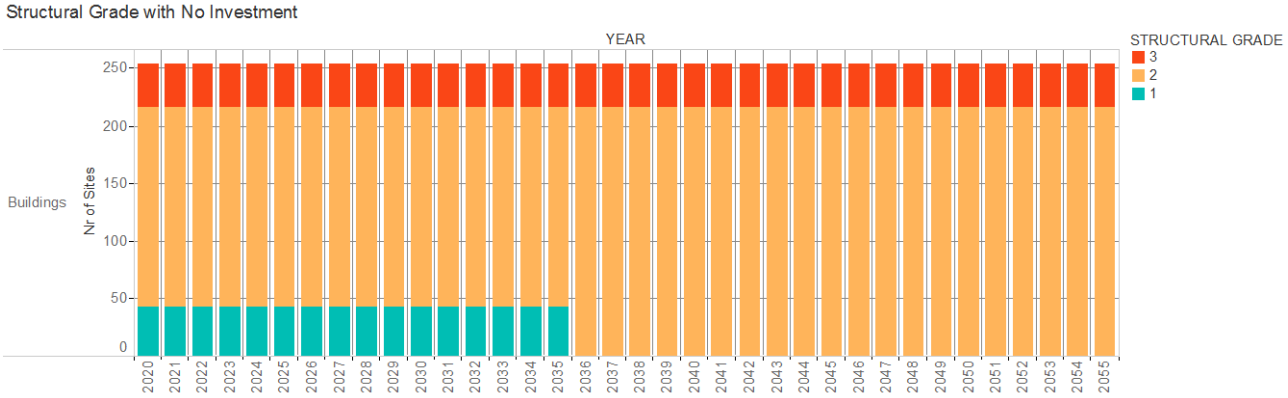
Impact of No Investment

27.7. Lack of early investment in buildings results in an increased whole life cost of the asset. Interventions later in the asset life (to remediate significant deterioration) are significantly more expensive than those undertaken early. Signs of deterioration are often visible, but these signs are easily ignored until severe deterioration occurs, at which point the safety and structural integrity of the asset is prejudiced and the cost of remediation dramatically increases.

27.8. Continued lack of investment in the buildings and enclosures leads to a failure to effectively protect the primary assets housed within them. This generally leads to an increased deterioration of these primary assets and ultimately their inability to perform effectively. The buildings and enclosures also require investment to enable them to continue to be a safe environment in which to operate and work on the NTS asset base.

27.9. The chart below shows the count of building assets by structural integrity inspection grades varying over time given no investment. Around 15% of assets are assessed as grade 3 in 2018.

Structural Grade – no Investment



Desired Outcomes

27.10. The outcome of this investment is to:

- Provide a safe working environment for all our staff
- Ensure that the buildings and enclosures are not a cause of the accelerated deterioration of or damage to our operational assets

Example of the Problem

27.11. The photographs below show examples and a description for each structural condition grade for the building assets. These are used for the site inspections and categorisation of the resulting grades. They are fully representative of the issues found on the sites.

Structural Condition Grades for Building Assets

Visual Grade	Description	Examples
❶	**No likely risk of disruption to service.**	 
No Remedial Action Required	Buildings and enclosures are new or in good condition, no evidence of water ingress that could damage equipment. Any associated; gutters, downpipes, doors, windows, building services, cladding, roof-lights, etc., are new or in good condition.	
❷	Potential for disruption to service	 
Minor Remedial Action Required	Buildings and enclosures are showing signs of deterioration, e.g; corroded cladding or fixings, cracks indicating minor settlement, signs of water ingress, associated items such as; gutters, downpipes, doors, windows, building services, cladding, roof-lights, etc., are showing signs of deterioration e.g; blocked gutters, loosening doors window fixings, flaking paint or protective surfaces. Arrange minor repairs, replace / re-fix hinges, identify and where practical seal water-leaks. More significant deterioration should be reported to 'Site Care' or recorded as a defect as appropriate.	
❸	**Likely disruption to service / damage to equipment from water ingress or hazards to site users.**	 
Remedial Action Required	Buildings and enclosures are significantly deteriorating, e.g; severe corrosion, loose cladding or fixings, open cracks indicating settlement, regular water ingress, associated items such as; gutters, downpipes, doors, windows, building services, cladding, roof-lights, gutters, protective surfaces /paint etc., has failed /come loose. .	

Spend Boundaries

27.12. The proposed investment includes all general building and enclosures on the NTS, including any 'no-regrets' site investments at both St Fergus and Bacton to keep them safe and operational whilst the separate funding mechanism for the proposed projects are progressed via Uncertainty Mechanisms.

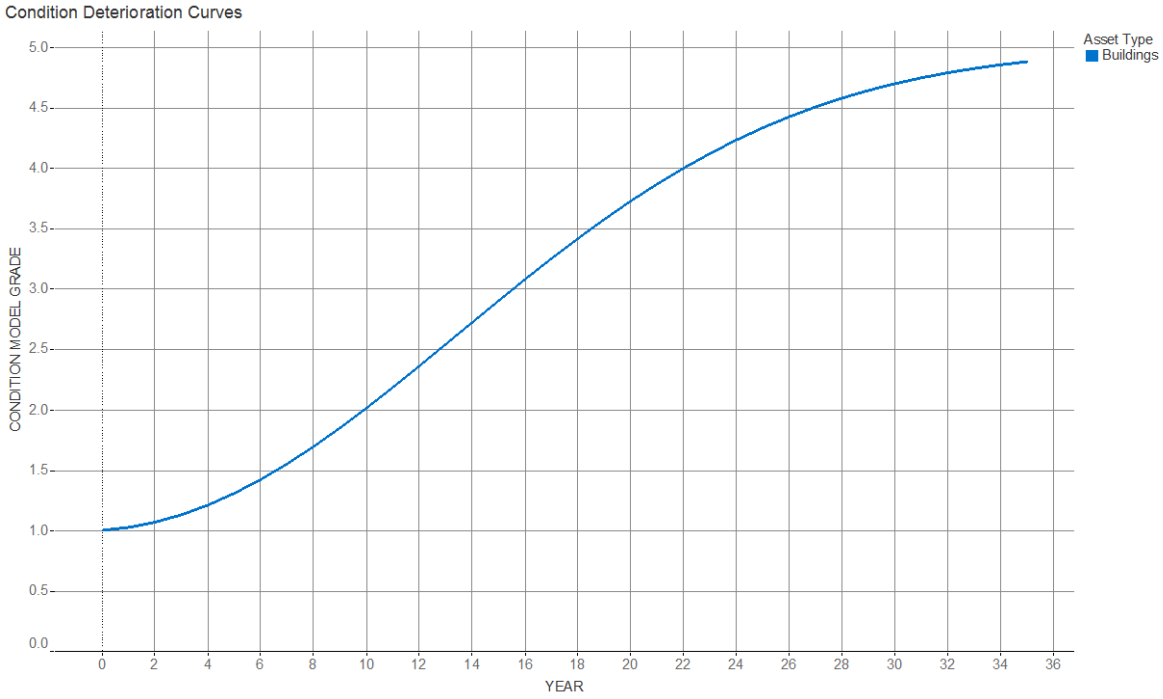
27.13. All buildings that house the compressor train are covered in the Cab Infrastructure justification paper.

28. Buildings and Enclosures - Probability of Failure

28.1. The chart below shows the condition deterioration curve for buildings structural integrity assets. The model uses the parameters derived within the development of our NOMS methodology showing how the asset degrades over time from Condition Model Grade 1 to Grade 5. Grade 5 is reached sometime after 35 years from new. Each grade is directly aligned to the asset health definitions used in RIIO-1.

Condition Deterioration Curve – Buildings Assets

Asset Health Scores	
AH1	New or as new
AH2	Good or serviceable condition
AH3	Deterioration, requires assessment or monitoring
AH4	Material deterioration, intervention requires consideration
AH5	End of serviceable life, intervention required



Probability of Failure

28.2. All Structural Integrity interventions are defined as consequential Interventions. This is because the prime function of Structural Integrity assets is to either support or protect enabling a dependent asset/site to perform its primary function of safely and reliably transporting gas. All risk benefits associated with Structural Integrity assets are therefore considered to align with the following definition of a consequential risk intervention:

*"Any intervention on a network asset, or other infrastructure asset, that modifies the probability of failure, or consequence of failure of **another network asset**. A consequential asset can include, for example:*

- *installation or removal of physical infrastructure designed to prevent damage to adjacent assets in the event of an asset failure (e.g. installation of a blast wall),*

- *addition or disposal that increases or decreases the resilience of a local or regional network and hence modifies the consequence of failure of other asset(s) in the locality or region."*

Consequential Interventions

28.3. The table below shows the drivers for Structural Integrity asset investment that are defined

Investment Drivers

NARMs Asset Intervention Category	Secondary Asset Classes
Consequential Interventions (Non-risk tradeable)	Civil assets - buildings/ enclosures

28.4. Our NOMs Methodology attempts to model the indirect benefits delivered by these assets in terms of the reduction in PoF or Consequence of Failure (CoF) upon a related and/or adjacent asset (e.g. the relationship between the pipe support and the pipework it is supporting). These quantified, but indirect, impacts are used within the CBAs accompanying this justification report but are not considered to be reliable enough for use as a NARMs monetised risk metric.

Structural Integrity Interventions

28.5. The table below provides the interventions for the structural integrity assets.

Interventions by Category

Intervention	SAC	Intervention Category
A22.03.2.4 / Minor remediation works (Bacton)	Civil assets - buildings/ enclosures	Minor Refurbishment
A22.03.2.5 / Monitoring of Structural Integrity Assets (Bacton)	Civil assets - buildings/ enclosures	Minor Refurbishment
A22.03.2.6 / Major remediation works (Bacton)	Civil assets - buildings/ enclosures	Major Refurbishment
A22.18.2.5 / Monitoring of Structural Integrity Assets	Civil assets - buildings/ enclosures	Survey
A22.18.2.6 / Minor remediation works	Civil assets - buildings/ enclosures	Minor Refurbishment
A22.18.2.7 / Buildings & Enclosures at AGIs Major Refurb	Civil assets - buildings/ enclosures	Major Refurbishment
A22.18.2.8 / Relifing of Buildings & Enclosures at Compressor Sites	Civil assets - buildings/ enclosures	Major Refurbishment

Data Assurance

28.6. All PoF and CoF values are taken from the National Grid Gas Transmission 'Methodology for Network Output Measures' (the Methodology). The Methodology was originally submitted for public consultation in April 2018, with three generally favourable responses received in May 2018. On this basis, Ofgem were happy to provisionally not reject the Methodology pending further work to:

- Produce a detailed Validation Report, confirming the validity of data sources used in the Methodology

- Test a range of supply and demand scenarios and incorporate an appropriate scenario to best represent Availability and Reliability risk

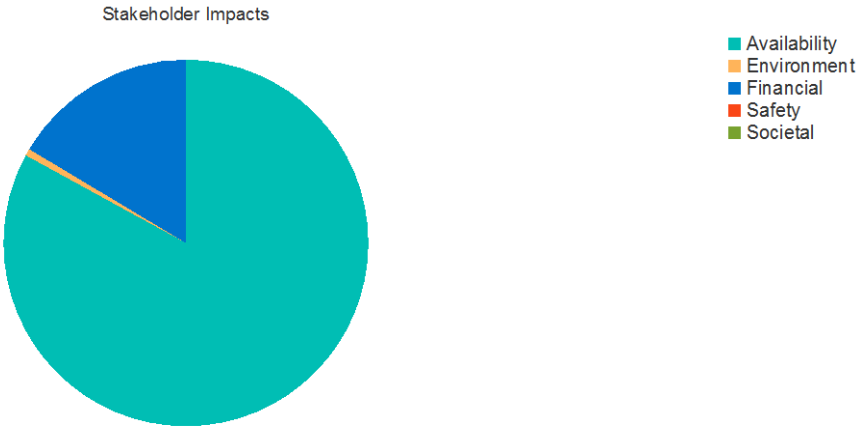
28.7. A review of the Methodology by independent gas transmission experts has been carried out and several improvements identified and incorporated.

28.8. At the time of writing, the final Validation Report has been submitted to Ofgem. We understand that once this work is complete Ofgem will formally “not reject” the Methodology and a License change progressed to restate our RIIO-1 targets in terms of monetised risk commenced.

29. Buildings and Enclosures - Consequence of Failure

29.1. The pie chart below shows the impacts on outcomes for stakeholders that we expect from failures or defects occurring on buildings structural integrity assets. The charts show the relative numbers of consequence events, not relative monetised risk.

Stakeholder Impacts



29.2. Buildings are used to house, equipment, staff and materials used to safely and reliably maintain the operation of the site. The risk associated with the building primarily depends on its purpose. The contribution of individual service risk measures towards the overall risk for Buildings can be explained as follows, in order of significance:

- **Availability risk** is associated with the inability to access a site to undertake operations, or where a structural failure of the building directly, causes an asset outage and the inability to maintain service
- **Financial risk** is associated with the costs of operating and maintaining the asset at the current level of risk, including routine inspection and maintenance activities Minor repairs are included but life extending interventions are considered as proactive interventions
- **Environmental risk** is negligible, but related to the environmental emissions associated with maintaining the building asset, including any gas losses causes by structural failures on assets housed within the building

30. Buildings and Enclosures - Options Considered

Potential Intervention Options

30.1. The following intervention categories apply to the building assets:

Repair

- Replace any broken elements such as gutters, downpipes, hinges, locks, handles, small roof repairs. Patch paint. Engage specialist to encapsulate any Asbestos Containing Material (ACM) if present.

Refurbishment

- Renew roof covering, reseal all joints, replace guttering and down-pipe system, update any internal electrics, heating / ventilating / cooling systems, renew key moving parts such as doors, windows, locks, etc. full re-paint internally and externally of any painted surfaces. Arrange specialist to remove any ACM.

Replace

- Construct new concrete base, foundations and divert cable ducting where required. Place new GRP or similar kiosk / building in accordance with specification. Demolish existing and transfer all services / electrical supplies etc., to new building.

Management of Asbestos

- Whenever Asbestos is encountered or likely to be disturbed for Asset Health works, it will be removed when practical, elsewhere it will be encapsulated and is managed in accordance with the statutory Asbestos management plans at sites. Management of deteriorating assets with Asbestos Containing Materials (ACM) will be subject to ongoing survey and monitoring works in addition to any specific costs relating to dealing with the ACM during any Asset Health Works.

Intervention Unit Costs

30.2. The total RIIO-2 investment for Buildings and Enclosures represents 4% of the Structural Integrity investment theme. 100% of costs for Buildings and Enclosures have been developed using other estimation methods due to the unavailability of outturn cost data and the broad spectrum of activities that can be performed to resolve the defect.

30.3. The table below provides the unit costs for all the potential building and enclosure interventions.

Intervention Unit Costs – Buildings & Enclosures

Intervention	Cost (£)	Unit	Evidence	Data Points	Overall value in BP
Buildings and Enclosures					
A22.03.2.4 / Minor remediation works (Bacton)	[redacted]	Per site	Estimated - Other	0	£91,297
A22.03.2.5 / Monitoring of Structural Integrity Assets (Bacton)	[redacted]	Per asset	Estimated - Other	0	£228,162
A22.03.2.6 / Major remediation works (Bacton)	[redacted]	Per site	Estimated - Other	0	£811,099
A22.18.2.5 / Monitoring of Structural Integrity Assets	[redacted]	Per asset	Estimated - Other	5	£327,996
A22.18.2.6 / Minor remediation works	[redacted]	Per site	Estimated - Other	0	£164,056
A22.18.2.8 / Relifing of Buildings & Enclosures at Compressor Sites	[redacted]	Per site	Estimated - Other	0	£1,236,667

A22.18.2.7 / Buildings & Enclosures at AGIs Major Refurb	[redacted]	Per site	Estimated - Other	0	£0

Access Equipment

31. Access - Equipment Summary

31.1. It is an important asset because it allows safe access and egress for all NG sites. It includes access roads from the Public Highway, site roads and associated paving, kerbs, parking and lay-down areas. These are found on virtually every operational site; their purpose is to provide safe access to and around sites to support safe maintenance and operational activities.

31.2. Bollards and steel barriers, sometimes known as Armco or crash barriers, may be positioned along roadways to protect nearby assets from damage that could be caused because of impact from vehicles or machinery using roadways.

31.3. The assets also include permanently fixed access and lifting equipment such as ladders, platforms, beams and davit sockets to support mobile lifting equipment. These all enable safe and efficient operation and maintenance activities.

32. Access - Problem Statement

32.1. The access roads, pavement and other structures were installed when the NTS sites were built, they have an average age of 37 years. The access roads, pavement and other areas are subject to deterioration. They require investment to ensure that they maintain their ability to provide a safe access, movement and egress for NG staff and for those that are located outside the site boundary meet our duty of care to members of the public.

32.2. Individual access items such as ladders, platforms and handrails are subject to corrosion and increasing defects are being found. A proportion of these assets also need to be updated to meet current good practice guidance for working at heights and therefore fulfil NG compliance with H&S legislation.

Drivers for Investment

32.3. The key drivers for investment in the access assets are:

- Asset Deterioration
- Legislation

32.4. Access assets deteriorate over time and with use which leads to their inability to perform their required function. This can also result in them no longer complying with direct legislative requirements.

32.5. Deterioration – the assets are subject to several deterioration mechanisms

- tarmac roads, pavements and other areas are subject to deterioration due to wear and the impact of the environment which leads to breakup of the tarmac and potholes.
- concrete elements deteriorate due to age and environmental effects which in turn then exposes any reinforcement which further deteriorates and spalls the concrete leading to further deterioration and ultimately structural failure
- the metal parts of ladders, platforms and handrails are subject to corrosion which can lead to failure or the inability of any moving parts to operate

32.6. Legislation - the access assets are essential in NG compliance with H&S in providing a safe working environment. Ladders and platforms also need to be updated to meet current good practice guidance for working at heights and therefore fulfil compliance with H&S legislation.

Impact of No Investment

32.7. Lack of investment in the access assets leads to their deterioration and inability to provide a safe working environment on NG operational sites. Certain elements of access such as ladders also need to continue to meet good practice and legislative requirements.

32.8. Deterioration of the access assets as the potential to cause significant safety hazards for those working on a site. The assets present a potential for trips and falls in an operational environment that is required to be safely accessed 24/7. This risk is further increased during darkness, bad weather and when there is a snow covering.

32.9. It is important to note that what might be considered as small potholes in good conditions, are a much more significant risk in adverse conditions, which is the typical

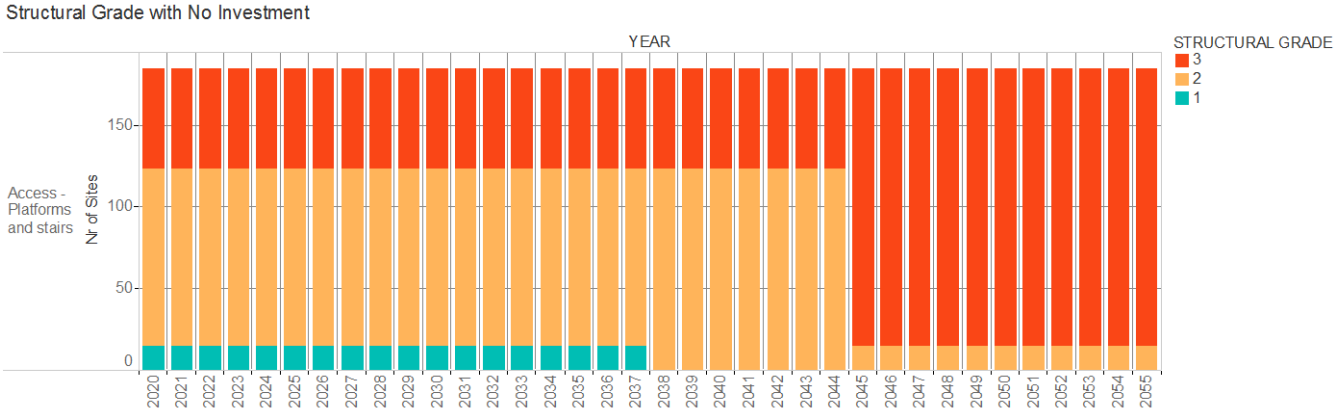
time when we need to get to and operate our sites safely, often by staff who are not necessarily familiar with the site layout. Consider these assets when there is even a modest 30mm snow cover and at night; trip-hazards are invisible, potholes are full of water and frozen over, etc.

32.10. Lack of investment in the ladders and platforms will render them non-compliant with current good practice guidance for working at heights and therefore not fulfil compliance with H&S legislation.

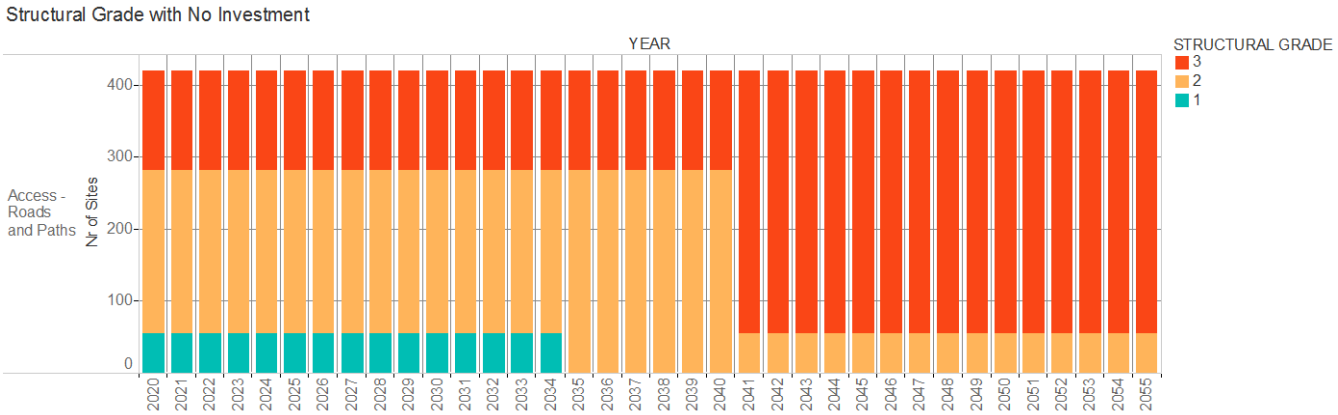
32.11. A significant impact from the lack of early investment in access is an increased whole life cost of the asset. Interventions later in the asset life (to remediate significant deterioration) are significantly more expensive than those undertaken early. Signs of deterioration are often visible, in the form of potholes, cracks and delamination, but these signs are easily ignored until severe deterioration occurs, at which point the safety and integrity of the asset is prejudiced and the cost of remediation dramatically increases.

32.12. The chart below shows the count of access assets by structural integrity inspection grades varying over time given no investment. Around 30% of assets are assessed as grade 3 in 2018 with nearly 60% assessed as grade 2.

Access Platforms and Stairs - Structural Grades – No Investment



Access Roads and Paths - Structural Grades – No Investment



Desired Outcomes

32.13. The outcome of this investment is to:

- Provide safe access and egress to and from all our site and maintain our duty of care to members of the public where we have roads and pavements that are subject to public access
- Ensure legal compliance of all ladders and other relevant fixed access assets.

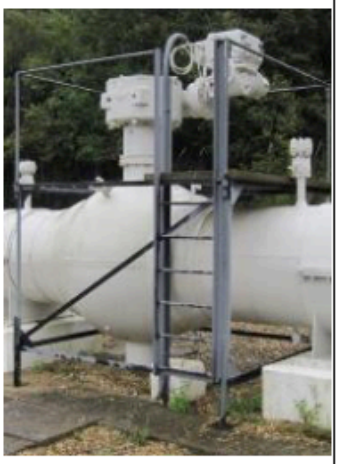
Example of the Problem

32.14. The photographs below show examples and a description for each structural condition grade for the access assets. These are used for the site inspections and categorisation of the resulting grades. They are fully representative of the issues found on the sites.

Structural Condition Grades - Site and Access Roads

Visual Grade	Description	Examples	
1	No likely risk of disruption of service.		
No Remedial Action Required	Road surface, kerbs and line-markings are new or in good condition, no visible surface deterioration, depression or damage to kerbs. Responsibility includes from start of access road at junction with the Public Highway.		
2	Potential for disruption to service		
Minor Remedial Action Required	Road surface, kerbs and line-markings are in serviceable condition but with some signs of deterioration e.g; patches (<1m2) of visible surface break-up, minor depressions or shallow (<30mm) pot-holes, loss of some concrete slab expansion joint material, damage to or settlement of kerbs. Responsibility includes from start of access road at junction with the Public Highway and throughout site. Arrange minor repairs, pot-hole filling, replacement expansion joint sealants to protect asset form further deterioration and to ensure continuing safety to users (including public on access roads). Where National Grid is not responsible then report fault to appropriate land-owner / authority.		
3	Progressive deterioration of the roads with trip hazards present.		
Remedial Action Required	Road surface, kerbs and line-markings are significantly deteriorated, e.g; large (>1m2) patches of visible surface break-up, depressions or deep (>30mm) pot-holes, extensive loss of concrete slab expansion joint material, damage to or settlement of kerbs. Responsibility includes from start of access road at junction with the Public Highway and throughout site. Raise a defect for issues identified and record all defect numbers in the report.		

Structural Condition Grades - Platforms, Stairs and Ladders

Visual Grade	Description	Examples
1	**No likely risk of disruption to service.**	 
No Remedial Action Required	Access assets such as; platforms, stairs and ladders are new or in good condition and are suitably designed to meet the purpose they are there for, e.g. safe access to enable valve maintenance. Self-closing gates and safety railing present as appropriate around any raised platforms. Concrete foundation slabs supporting the equipment are new or good condition.	
2	**Potential for trips fall hazards to users.**	 
Minor Remedial Action Required	Access assets such as; platforms, stairs and ladders are in serviceable condition and generally meet the purpose they are there for, e.g. safe access to enable valve maintenance. Self-closing gates and safety railing present as appropriate around any raised platforms. Concrete foundation slabs supporting the assets is showing signs of deterioration. Arrange minor repairs to deteriorating concrete, replace / re-fix any self-closing gates or loose handrails and safety equipment associated with access.	
3	**Access assets in poor condition, missing or likely to present trip or fall hazards to users.**	 
Remedial Action Required	Access assets such as; platforms, stairs and ladders are in poor condition and fail to meet the purpose they are needed for, e.g. obstruct safe access for valve maintenance, gaps in safety railing around any raised platforms, missing self-closing gates. Concrete foundation slabs supporting the equipment is deteriorating and/or fixings coming loose. In the event of unsafe equipment being identified it should be labelled to indicate it shouldn't be used and made in-accessible where possible, e.g. hazard warning tape. Raise a defect for issues identified and record all defect numbers in the report.	

Spend Boundaries

32.15. The proposed investment includes all fixed access assets on the NTS, including any 'no-regrets' site investments at both St Fergus and Bacton to keep them safe and operational whilst the separate funding mechanism for the proposed projects are progressed via Uncertainty Mechanisms.

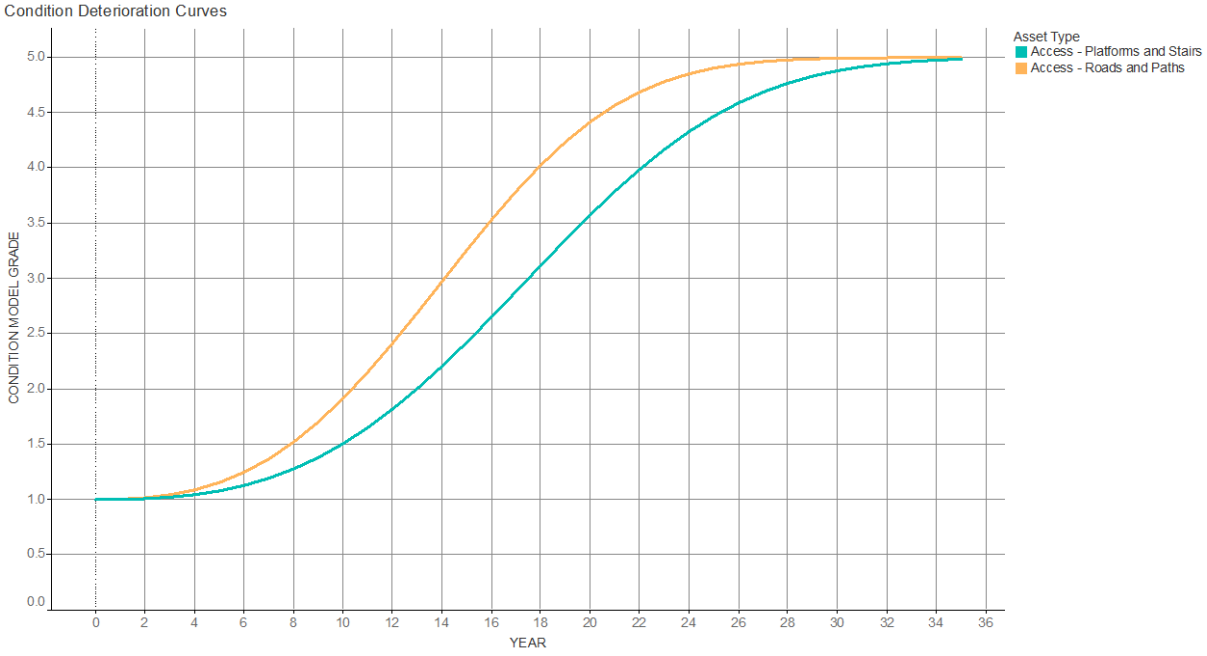
32.16. The investment excludes mobile equipment such as MEWPs, cherry pickers, and ropes, harnesses, strops, and similar useable equipment, this is included in tools and equipment.

33. Access - Probability of Failure

33.1. The chart below shows the condition deterioration curves for access structural integrity asset types. The models use the parameters derived within the development of our NOMS methodology showing how the asset degrades over time from Condition Model Grade 1 to Grade 5. Grade 5 is reached at around 30 years for platforms and stairs, and sometime after 35 years for roads and paths from new. Each grade is directly aligned to the asset health definitions used in RIIO-1.

Condition Deterioration Curves – Access asset types

Asset Health Scores	
AH1	New or as new
AH2	Good or serviceable condition
AH3	Deterioration, requires assessment or monitoring
AH4	Material deterioration, intervention requires consideration
AH5	End of serviceable life, intervention required



Probability of Failure

33.2. All Structural Integrity interventions are defined as consequential Interventions. This is because the prime function of Structural Integrity assets is to either support or protect enabling a dependent asset/site to perform its primary function of safely and reliably transporting gas. All risk benefits associated with Structural Integrity assets are therefore considered to align with the following definition of a consequential risk intervention:

*"Any intervention on a network asset, or other infrastructure asset, that modifies the probability of failure, or consequence of failure of **another network asset**. A consequential asset can include, for example:*

- *installation or removal of physical infrastructure designed to prevent damage to adjacent assets in the event of an asset failure (e.g. installation of a blast wall)*

- *addition or disposal that increases or decreases the resilience of a local or regional network and hence modifies the consequence of failure of other asset(s) in the locality or region."*

Consequential Interventions

33.3. The table below shows the drivers for Structural Integrity asset investment that are defined

Investment Drivers

NARMs Asset Intervention Category	Secondary Asset Classes
Consequential Interventions (Non-risk tradeable)	Civil assets – access

33.4. Our NOMs Methodology attempts to model the indirect benefits delivered by these assets in terms of the reduction in PoF or Consequence of Failure (CoF) upon a related and/or adjacent asset (e.g. the relationship between the pipe support and the pipework it is supporting). These quantified, but indirect, impacts are used within the CBAs accompanying this justification report but are not considered to be reliable enough for use as a NARMs monetised risk metric.

Structural Integrity Interventions

33.5. The table below provides the interventions for the structural integrity assets.

Intervention Options

intervention	SAC	Intervention Category
A22.03.2.1 / Minor remediation works (Bacton)	Civil assets - access	Minor Refurbishment
A22.03.2.2 / Monitoring of Structural Integrity Assets (Bacton)	Civil assets - access	Minor Refurbishment
A22.03.2.3 / Major remediation works (Bacton)	Civil assets - access	Major Refurbishment
A22.18.2.1 / Monitoring of Structural Integrity Assets	Civil assets - access	Survey
A22.18.2.2 / Minor remediation works	Civil assets - access	Minor Refurbishment
A22.18.2.3 / G2/G3 Access Platforms & Stairs Relifing	Civil assets - access	Major Refurbishment
A22.18.2.4 / Site Access Roads and Paths Major Refurb	Civil assets - access	Major Refurbishment
A22.22.2.2 / Access Road Monitoring & Replacement (St. Fergus)	Civil assets - access	Replacement

Data Assurance

33.6. All PoF and CoF values are taken from the National Grid Gas Transmission 'Methodology for Network Output Measures' (the Methodology). The Methodology was originally submitted for public consultation in April 2018, with three generally favourable responses received in May 2018. On this basis, Ofgem were happy to provisionally not reject the Methodology pending further work to:

- Produce a detailed Validation Report, confirming the validity of data sources used in the Methodology
- Test a range of supply and demand scenarios and incorporate an appropriate scenario to best represent Availability and Reliability risk

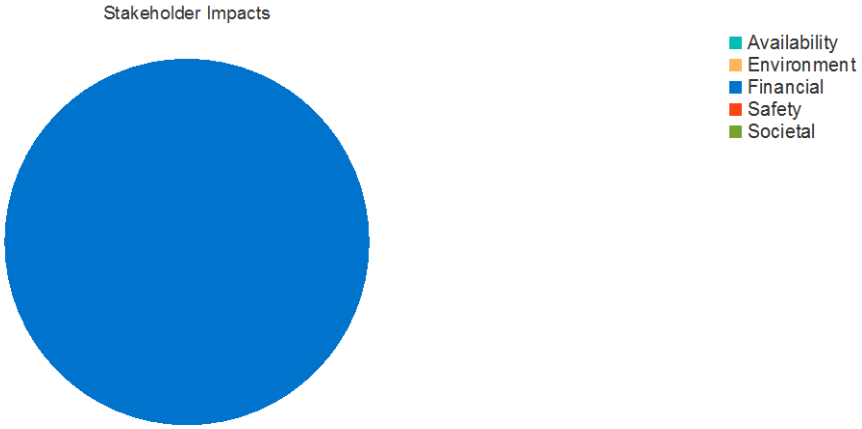
33.7. A review of the Methodology by independent gas transmission experts has been carried out and several improvements identified and incorporated.

33.8. At the time of writing, the final Validation Report has been submitted to Ofgem. We understand that once this work is complete Ofgem will formally “not reject” the Methodology and a License change progressed to restate our RIIO-1 targets in terms of monetised risk commenced.

34. Access - Consequence of Failure

34.1. The pie chart below shows the impacts on outcomes for stakeholders that we expect from failures or defects occurring on access structural integrity assets. The charts show the relative numbers of consequence events, not relative monetised risk.

Stakeholder Impacts - Access



34.2. Access assets relate to the roads and pathways serving an NTS site. Although essential to allow safe and reliable access to assets for maintenance and repair, the risks carried by these assets are generally indirect (i.e. preventing swift ingress and/or egress). Therefore, there is a single service risk consequence attributed to Access assets:

- **Financial risk** is mostly associated with the costs of operating and maintaining the asset at the current level of risk. Any work extending the life of these assets is considered as proactive maintenance and is not included in the baseline risk value

35. Access - Options Considered

Potential Intervention Options

35.1. The following intervention options apply to the access assets:

35.2. Access Roads and Pavements

- **Repair** - Pot-hole filling, patch repairing, re-levelling paving slabs, kerbs and renew white / yellow demarcation lines.
- **Refurbishment** - Plane off the top layers of tarmac / concrete and lay new topping surfaces. Replace any gullys and broken kerbs.
- **Replacement** - Remove entire road construction to sub-base and reconstruct, including new kerb, gullys and catch-pits.

35.3. Fixed Access Equipment

- **Repair -** Cut out and replace any corroded / damaged elements of access structures such as hand-rails / platform floors, repair damaged foundations or loose fittings / fixing anchors.
- **Refurbishment -** Add self-closing gates to raised platforms where needed, re-paint, replace elements that no longer conform to current specifications, add kicker boards, additional steps, etc. Extend railings to close any gaps.
- **Replacement -** Remove vertical ladders, platforms, gates, fall inhibitor systems, etc. And replace where possible with stairs and platforms conforming to current specifications.

Intervention Unit Costs

35.4. The total RIIO-2 investment for Access represents 14% of the Structural Integrity investment theme. 71% of unit costs that support the Access investment are based on historical outturn cost data points. The remaining 29% of costs have been developed using other estimation methods due to the unavailability of outturn cost data and the broad spectrum of activities that can be performed to resolve the defect.

35.5. The table below provides the unit costs for all the access interventions.

Intervention Unit Costs - Access

Intervention	Cost (£)	Unit	Evidence	Data Points	Overall value in BP
Access					
A22.18.2.1 / Monitoring of Structural Integrity Assets	[redacted]	Per asset	Estimated - Other	5	£415,793
A22.18.2.2 / Minor remediation works	[redacted]	Per site	Estimated - Other	0	£207,970
A22.18.2.3 / G2/G3 Access Platforms & Stairs Relifing	[redacted]	Per asset	Estimated - Other	0	£1,177,778
A22.18.2.4 / Site Access Roads and Paths Major Refurb	[redacted]	Per site	Outturn	2	£7,801,300
A22.03.2.1 / Minor remediation works (Bacton)	[redacted]	Per site	Estimated - Other	0	£89,000
A22.03.2.2 / Monitoring of Structural Integrity Assets (Bacton)	[redacted]	Per asset	Estimated - Other	0	£222,422
A22.03.2.3 / Major remediation works (Bacton)	[redacted]	Per site	Estimated - Other	0	£790,694

A22.22.2.2 / Access Road Monitoring & Replacement (St. Fergus)	[redacted]	Per site	Estimated - Other	0	£289,220

Business Case

In this section, we set out our overall investment plan for security, access and buildings assets. This section demonstrates why the proposed investment levels are the right levels to ensure the health and reliability of these assets for the investment period and beyond.

36. Business Case Outline and Discussion

Key Business Case Drivers Description

36.1. The key drivers for investment in the security, buildings and access assets are:

- Legislation
- Asset Deterioration

Business Case Summary

36.2. In appraising asset health investment, we have considered how assets can impact on several outcomes:

- Reliability risk
- Environmental risk
- Safety risk
- Impact on wider society

36.3. Failures of these assets can impact on these outcomes, particularly safety of our staff and members of the public. Availability of the primary assets can also be impacted by the deterioration of the building assets if they should fail to provide adequate protection.

Outcomes Delivered

36.4. The outcome of this investment is to:

- Ensure the security on the highest risk (Non-ISS sites) is maintained to a level where the risk of third-party intrusion is managed and the effect on the operation of the assets is minimised.
- Provide a safe working environment for all our staff
- Maintain our duty of care to members of the public
- Ensure that the buildings and enclosures are not a cause of the accelerated deterioration of or damage to our operational assets
- Ensure ladders and other fixed access equipment remain compliant with legislation

Stakeholder Support

36.5. Consumer and stakeholder research and engagement has been integral to the development of our asset health investment plans. Early discussions realised that to engage in meaningful dialogue, our plan outputs should be presented at a programme rather than asset level of detail. This is due to the integrated nature of our Asset Health plan which makes it challenging to disaggregate and engage on individual elements.

For details of our stakeholder engagement approach please refer to ‘I want to take gas on and off the system where and when I want’ Chapter 14 of the GT submission.

37. Programme Options

Programme Option Overview

37.1. Our aim in developing the investment plan is to deliver value to our consumers and stakeholders. Hence, we have considered a range of options from the do nothing position through to reductions in risk across all the measures. These have been used to explore the credible options for varying the investment and the appraising the impacts on our legal compliance, risk position and stakeholders.

37.2. In developing our plan, the following options have been considered for investment in the security, access and building assets. Please note that all programme options include any fixed 'no-regrets' investments associated with the Bacton and St Fergus sites.

Baseline – Do Nothing

37.3. The impact of no investment in our Security, Access Roads and Buildings is an increase in service risk over a 10-year period. The most significant impact being a twelve-fold increase in the potential number of fatalities every year resulting from persons inadvertently and intentionally coming into potential contact, or within the vicinity of our operational assets and the risk associated with doing so. This option includes the reactive only investment across all Security, Access Roads and Buildings and is the option against which all the other options are compared.

Programme Option 1 – Fix on Fail

37.4. This option does not include any monitoring of the security access and building assets and undertakes minimal reactive minor refurbishment to the assets as and when they fail. No proactive replacement is undertaken with only the minimal amount of either minor or major refurbishment work to the function of the asset.

37.5. The option does include the investment required in our ladder and platform assets to meet good practice guidance for working at heights and therefore fulfil compliance with H&S legislation.

Programme Option 2 – Primary Proactive Re-lifing

37.6. This option considers minimal proactive re-lifing of those assets that have a direct potential impact on the primary assets and/or the safety of staff and members of the public. Only the worst grade assets are fully assessed and considered for re-lifing (refurbishment / replacement) investment. All other assets are fixed on failure / non-compliance with the minimal amount of either minor or major refurbishment work undertaken to restore the function of the asset.

37.7. The option does include the investment required in our ladder and platform assets to meet good practice guidance for working at heights and therefore fulfil compliance with H&S legislation.

Programme Option 3 – Minimal Proactive Re-lifing

37.8. This option considers minimal proactive re-lifing across all asset types with only the oldest worst condition/performing assets fully assessed and considered for re-lifing investment. All other assets are fixed on failure / non-compliance with the minimal amount of either minor or major refurbishment work undertaken to restore function of the asset.

37.9. The option includes the investment required in our ladder and platform assets to meet good practice guidance for working at heights and therefore fulfil compliance with H&S legislation.

Programme Option 4 – Risk Based Re-lifing

37.10. This option considers risk based re-lifing of the assets based on their condition, criticality and age. A decision on the level of re-lifing (refurbishment / replacement) is then made. There is some allowance for reactive fix on fail which will consist of the most appropriate minor / major refurbishment or replacement.

Programme Option 5 - Increased Proactive Re-lifing

37.11. This option considers increased proactive re-lifing based on asset condition with all assets considered for replacement at an earlier condition grade. A reduced allowance for fix on fail is included for some assets which deteriorate earlier in their lifecycle.

Programme Options Summary

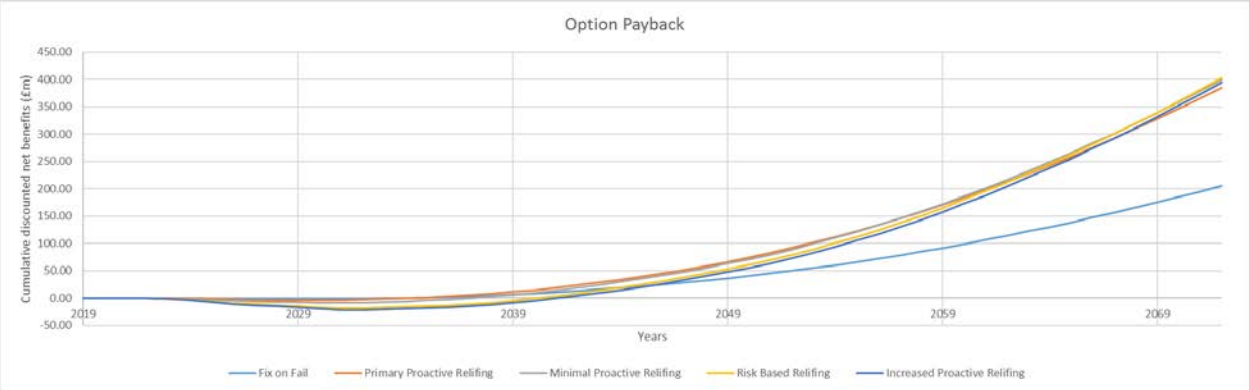
37.12. In considering the CBA for each of the programme options, a summary of all the potential programme options is provided in the table below.

Potential Programme Options

Option	RIIO-2 Invest' £ m	RIIO-3 Invest' £ m	PV Costs £ m	PV benefits £ m	Net NPV £ m	CB Ratio	Payback Period (years)
1 - Fix on Fail	£5.11	£13.44	£19.66	£167.17	£147.51	8.50	12
2 - Primary Proactive Re-lifing	£11.47	£17.51	£32.39	£307.76	£275.37	9.50	13
3 - Minimal Proactive Re-lifing	£19.19	£31.39	£55.91	£339.28	£283.38	6.07	16
4 - Risk Based Re-lifing	£33.69	£56.85	£98.11	£379.98	£281.87	3.87	19
5 - Increased Proactive Re-lifing	£37.59	£60.94	£106.23	£380.10	£273.87	3.58	20

37.13. The graph shows the cumulative discounted NPV of the net benefit for each of the investment options.

Option Payback – Net NPV



Programme Options Selection

37.14. All the potential options are cost beneficial over the 45-year analysis period. The selection of the preferred option has been based on an assessment of the level of risk, maintaining our compliance with legislation and delivering value for consumers and stakeholders. The outcomes associated with each option are provided below:

Programme Option 1 – Fix on Fail

37.15. This option results in increased reactive re-lifing (i.e. fix on fail) across most of the security, access and building assets. As little or no monitoring is being undertaken assets are not worked on until they fail or are deemed non-compliant, so may be an effect on the availability of the compressors and other primary assets that impact the service delivered by the NTS as a whole. The overall safety and compliance risk from structural assets is increased. Reactive re-lifing is not a long-term solution for the assets so this option will defer significant expenditure to after RIIO-2 and RIIO-3 and increase the overall whole life costs of the assets.

Programme Option 2 – Primary Proactive Re-lifing

37.16. Whilst re-lifing some of the worst condition and oldest assets that directly affect other primary assets or safety, this option still results in unacceptable levels of impact on the primary assets and increases in safety and compliance risk. Significant expenditure is still deferred outside RIIO-2 and RIIO-3.

Programme Option 3 – Minimal Proactive Re-lifing

37.17. Whilst re-lifing some of the worst condition and oldest assets this option still results in unacceptable levels of impact on the primary assets and increases in safety and compliance risk. Significant expenditure is still deferred outside RIIO-2 and RIIO-3.

Programme Option 4 – Risk Based Re-lifing

37.18. A risk based re-lifing of the assets through a considered and appropriate mix of proactive major / minor refurbishment and replacement combined with some reactive fix on fail maintains the levels of risk impact on performance to current levels. There is minimal deferment of expenditure outside the RIIO-2 and RIIO-3 period. This option enables an acceptable level of investment to be maintained across the short and medium terms to manage the level of performance and risk.

Programme Option 5 - Increased Proactive Re-lifing

37.19. Increased proactive replacement and refurbishment reduces the risk of impacting the availability of operational assets and the associated service performance of the NTS. The number of failed assets is minimised however this is at the expense of increased investment in RIIO-2 and RIIO-3. This level of investment is not supported by stakeholders and results in an unachievable and unacceptable number of outages on the NTS to enable the work to be undertaken.

Preferred Option

37.20. Our preferred option is Option 4 to maintain the current level of risk. Other programme options require less investment and one is marginally more cost beneficial, however these options do not meet our desired outcomes. Option 4 is the option that, at lowest whole life cost, maintains the level of security on our sites, provides a safe working environment for our staff, does not result in accelerated deterioration of the operational assets and maintains our compliance with regards to fixed access equipment. Option 3 which is slightly more NPV positive is not preferred as the CBA does not properly recognise the levels of impact on the primary assets and increases in safety and compliance risk. The 2 options also have similar payback periods.

37.21. The selection of this option is consistent with feedback from our stakeholder engagement who wanted at least the current level of risk maintained.

37.22. A complete explanation of the selected option is provided in the next section.

38. Decision Approach and Benefits - Security and Fencing

38.1. In this section, we set out our investment decision approach for security and fencing together with the benefits of the investment.

Key Drivers

38.2. The key drivers for investment in the Security assets are:

- Asset Deterioration
- Changing Standards
- Legislation

Investment Decision Approach

38.3. To deliver the outcomes for the investment period the Security assets require a mixture of the intervention categories. The predicted volumes of investment for the period are derived from:

- Analysis of historical investment
- Results of the RIIO-1 inspections
- Current defects

38.4. This drives a predicted volume of:

- 150 sites to have replacement fences and associated assets, this will be on a like for like basis.
- 10 sites to have a significant re-lifing – i.e. replacement electric gates, CCTV cameras and associated assets.
- Ongoing repairs as required to the remaining security assets

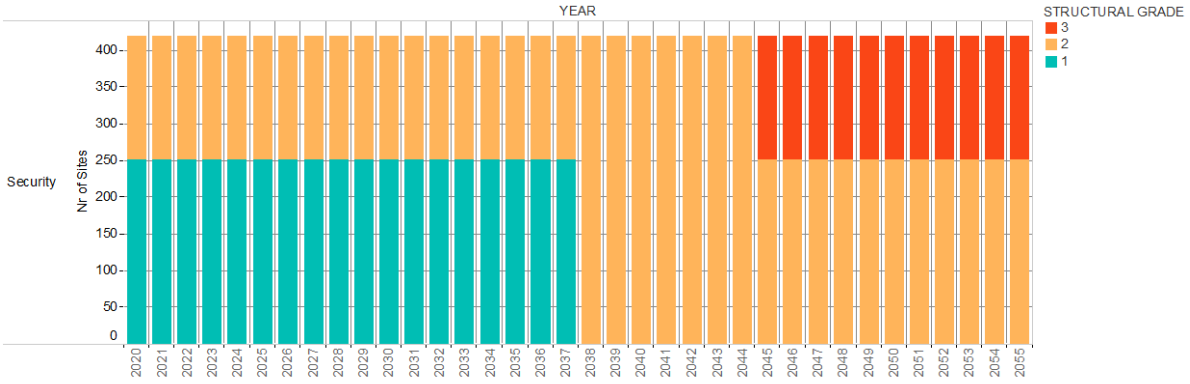
38.5. The chain link fence, electric gate, control systems and mechanical drive will be replaced during RIIO-2 with a fence to current non-ISS standards. This will mitigate the risks associated with the failing structural integrity of this electrified fence on this compressor site.

38.6. The proposed mix of interventions and programme of work will be continually reassessed and reprioritised based on the ongoing inspection and monitoring programme including other defects or plant status issues that are identified.

Benefits of Investment

38.7. The chart below shows the count of security assets by structural integrity inspection grades varying over time assuming the preferred investment option is applied. This shows that with the preferred investment option, the structural grade 3 assets are returned to grade 1 and even with ongoing deterioration, the assets remain at grade 1 or 2 until 2045.

Structural Grade – Preferred Investment Strategy



39. Decision Approach and Benefits - Buildings and Enclosures

39.1. In this section, we set out our investment decision approach for buildings and enclosures together with the benefits of the investment.

Key Drivers

39.2. The key drivers for investment in the buildings and enclosures are:

- Legislation
- Asset Deterioration

Investment Decision Approach

39.3. To deliver the outcomes for the investment period the buildings and enclosures require a mixture of intervention categories. The decision on the volume of each of the interventions required has been determined using the following methodology.

39.4. The predicted volumes of investment for the period are derived from:

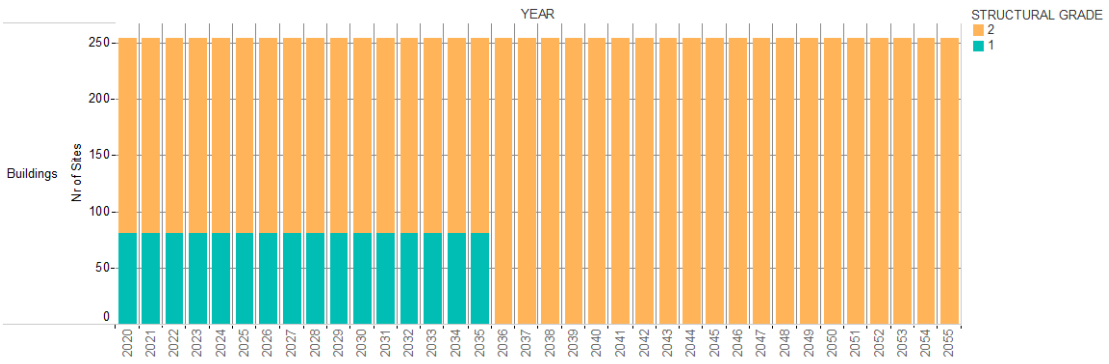
- analysis of historical investment
- knowledge from the RIIO-1 inspections
- current defects
- site criticality

39.5. The proposed mix of interventions and programme of work will be continually reassessed and reprioritised based on the ongoing inspection and monitoring programme including other defects or plant status issues that are identified.

Benefits of Investment

39.6. The chart below shows the count of building assets by structural integrity inspection grades varying over time assuming the preferred investment option is applied. This shows that with the preferred investment option, the structural grade 3 assets are returned to grade 1 and even with ongoing deterioration, the assets remain at grade 1 or 2 until at least 2055.

Structural Grades – Preferred Investment Strategy



40. Decision Approach and Benefits – Access Equipment

40.1. In this section, we set out our investment decision approach for access together with the benefits of the investment.

Key Drivers

40.2. The key drivers for investment in the Access assets are:

- Asset Deterioration
- Legislation

Investment Decision Approach

40.3. To deliver the outcomes for the investment period the Access assets require a mixture of the intervention categories. The decision on the volume of each of the interventions required has been determined using the following methodology.

40.4. Access Roads and Pavements

- During RIIO-1, access assets were mostly maintained with partial repairs and localised renewals. As the assets continue to deteriorate and more significant investment is needed, e.g. rather than re-surfacing / pot-hole filling access roads, complete reconstruction of roads is required. Less than 5% of these assets were renewed during RIIO-1, this rate must be increased to keep up with the rate of deterioration. Other sectors with similar assets such as Local Councils have experienced the same problems, where severe winters has driven water and salts deeper into structure, especially concrete roads, resulting in corrosion of the reinforcement accelerating the complete breakdown of the road structure. Evidence for this is Government report (2012) 'Potholes review'. This good asset management practice shows the benefits of an investment programme to renew surfacing using a proactive and planned approach.
- The investment proposed is to move to a proactive risk based inspection, monitoring and intervention regime to manage the access roads assets. By the end of RIIO-3 40% of sites with the highest risk access road and pavement assets will have proactive remediation work in the investment period. The remaining sites will be subject to a reactive approach driven by the reporting of specific issues. The level of reactive remediation has been based on historical data.

40.5. Fixed Access Equipment

- For fixed-access equipment a site by site assessment has been undertaken to ensure that by the end of RIIO-3 all access assets will have had the appropriate intervention to maintain legal compliance of these assets.

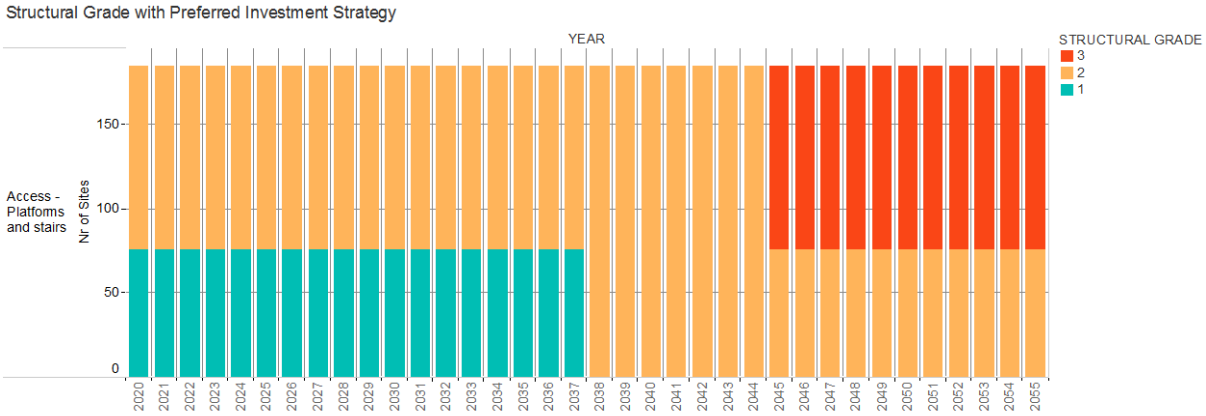
40.6. The proposed mix of interventions and programme of work will be continually reassessed and reprioritised based on the ongoing inspection and monitoring programme including other defects or plant status issues that are identified.

Benefits of the Investment

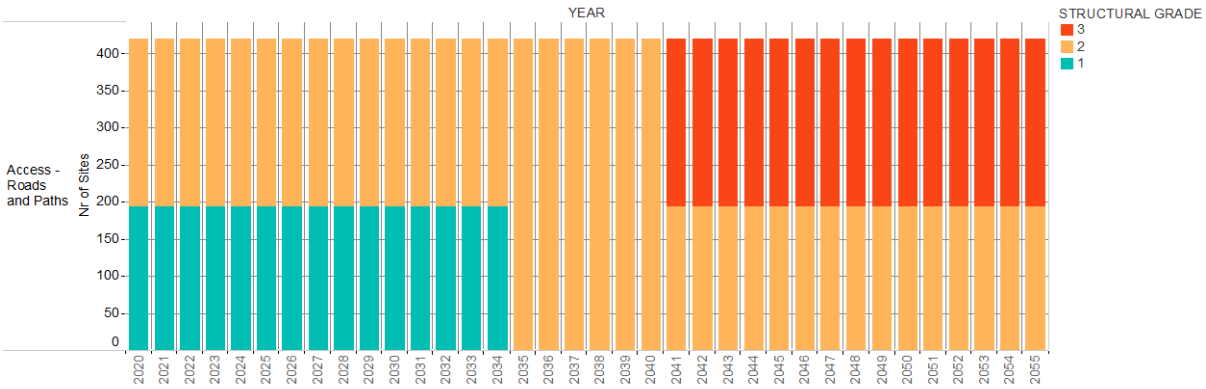
40.7. The chart below shows the count of access assets by structural integrity inspection grades varying over time assuming the preferred investment option is applied. This shows that with the preferred investment option, the structural grade 3 assets are

returned to grade 1 and even with ongoing deterioration, the assets remain at grade 1 or 2 until at least 2040 for roads and paths, and 2045 for platforms and stairs.

Access Platforms and Stairs - Structural Grades – Preferred Investment Strategy



Access Roads and Paths - Structural Grades – Preferred Investment Strategy



41. Business Case Summary

41.1. In this section we set out our overall investment plan for security, building and access assets protection.

Preferred option

41.2. To deliver the required outcomes for all our stakeholders we have developed the most effective combination of efficient interventions. These form the programme of work for the security, building and access assets in the investment period. [redacted]

Intervention Volumes

[redacted]		
[redacted]		
[redacted]		
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Asset Health Spend Profile

41.3. The profile of investment in the building, security and access assets, driven from the derived volumes of work and the efficient unit costs, for the period is shown is the table below:

Investment Profile

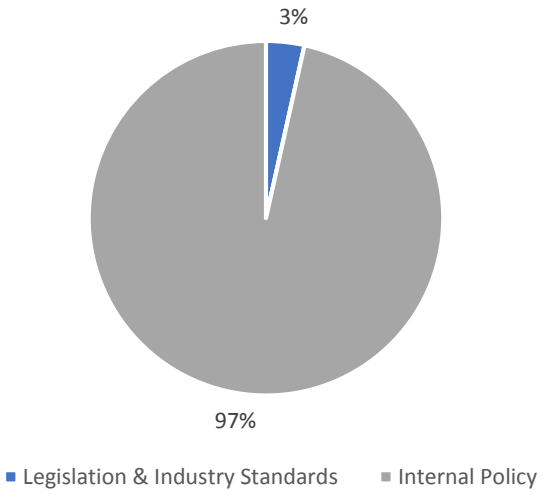
Investment (£ 000's)	RIIO-2					RIIO-3				
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031

Civil assets - access	157	800	2,458	4,261	3,317	2,431	3,153	3,023	2,680	1,952
Civil assets - buildings/ enclosures	304	590	533	825	608	4,033	4,022	4,022	4,022	4,022
Security	1,780	2,105	4,059	4,582	7,306	4,446	4,801	4,509	4,704	5,027
Total	2,242	3,495	7,050	9,668	11,230	10,911	11,976	11,554	11,405	11,001
	33,685					**56,847**				

Intervention Drivers

41.4. The following chart shows the breakdown of investment across each of the intervention drivers. This shows that whilst some of the investment consists of interventions that are required to meet legislative requirements and are based on accepted industry standards, the majority is based on internal policy.

RIIO-2 Security and Fencing, Access and Buildings Intervention Drivers[4]



Programme CBA

41.5. We are targeting an appropriate level of asset health investment to mitigate the reliability, safety and environmental risks from an ageing asset base.

41.6. In line with HM Treasury Green Book advice and Ofgem guidance we have appraised whether investment in security, access and buildings is value for money. We have considered costs over a 45-year period in a full cost benefit analysis (CBA).

41.7. The CBA shows that investment in these assets is cost beneficial over the 45-year period. This is shown below.

Cost Benefit Analysis[5]

	10 years	20 years	30 years	45 years
Present Value costs (£m)	£30.09	£50.19	£73.51	£98.11
Present Value H&S benefits (£m)	£0.01	£0.09	£0.43	£2.26
Present Value non H&S benefits (£m)	£11.29	£54.01	£142.35	£377.72
Net Present Value (£m)	£(18.80)	£3.90	£69.28	£281.87

41.8. We have challenged whether this is the right programme of work. In developing our plans and making our decision we have been fully cognisant of the need to develop plans that are value for money, acceptable, affordable and deliverable.

41.9. The level of investment in the security, access and buildings assets is essential in our compliance with legal obligations to provide safe working for our staff. Accelerated deterioration and damage to our primary operational assets is mitigated through the

[4] See Appendix A for intervention driver category definitions

[5] A14.19.2 Security and Fencing, Access and Buildings CBA

investment in ensuring the buildings are fit for purpose and provide adequate protection.

41.10. Investment in the security and access assets is required to provide safe access and egress to and from our sites 24 hours a day in all weather conditions. The investment also ensures that we maintain our duty of care to members of the public and our compliance with PSR.

41.11. Our inspection, monitoring and condition approach with early intervention is widely accepted as the lowest whole life cost of managing these long-life assets. In developing the proposed programme of work, we aimed to achieve the optimal balance between the level of investment and the risk to outcomes. We believe we have achieved this through a programme of re-lifing a proportion of the assets on a site by site basis whilst managing any individual defects on other sites on a case by case basis.

41.12. This approach achieves the balance of ensuring the assets remain fit for purpose in the medium term whilst maintaining affordable and deliverable levels of investment in the short term.

41.13. We have used the potential range of unit cost variance to assess the sensitivity of the Cost Benefit Analysis to the upper and lower limits. The graph below shows the results of this compared to the preferred option.

Net Benefits of Upper and Lower Unit Cost Sensitivity

41.14. Whilst the level of cost benefit and the payback period changes as the unit costs vary, the investment remains cost beneficial across the range of unit costs. The potential range of unit costs does not therefore change our decision.

41.15. This level of investment will ensure we successfully manage asset deterioration whilst meeting our legal obligations. It will ensure we deliver the outcomes that consumers and stakeholder tell us they want us to meet.

Preferred Option

42. Preferred Option Scope - Buildings, Security and Access

42.1. The section summarises our preferred investment plan required to deliver acceptable and affordable outcomes for our stakeholders.

Preferred option

42.2. To deliver the required outcomes for all our stakeholders we have developed the most effective combination of efficient interventions. These form the programme of work for the security, building and access assets in the investment period. [redacted]

Intervention Volumes

[redacted]		
[redacted]		
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Asset Health Spend Profile

42.3. The profile of investment in the building, security and access assets, driven from the derived volumes of work and the efficient unit costs, for the period is shown is the table below:

Investment Profile

Investment (£ 000's)	RIIO-2					RIIO-3				
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Civil assets - access	157	800	2,458	4,261	3,317	2,431	3,153	3,023	2,680	1,952
Civil assets - buildings/ enclosures	304	590	533	825	608	4,033	4,022	4,022	4,022	4,022
Security	1,780	2,105	4,059	4,582	7,306	4,446	4,801	4,509	4,704	5,027
Total	2,242	3,495	7,050	9,668	11,230	10,911	11,976	11,554	11,405	11,001
	33,685					**56,847**				

Delivery Planning

42.4. At this point in time the delivery of our RIIO-2 and RIIO-3 plans are in principle deliverable based on initial assessments of work. We will regularly review the plan to consider any known or changing constraints, customer impacts and bundling opportunities. In the event of churn our plan must be reoptimised to reflect the impact of the change and provide an opportunity to reconsider the efficient timing of delivery.

42.5. These items may not need outages or pressure reductions to achieve access, however in the case of ducting or buildings the isolation of assets may be necessary to avoid undesirable operations for example via damage to cabling. Fencing and access projects may require pressure reductions when crossing services.

42.6. In all cases a systematic approach therefore maximises the work undertaken in any outage whilst ensuring efficient delivery through minimised project overheads.

42.7. This approach is particularly effective when applied at a feeder level or for a whole site. In which case the preparatory inspection, investigation, risk assessment, planning and procurement activities can be completed as far as possible before the outage. This allows the maximum amount of intervention and risk reduction to be bundled into a single 'campaign' across the length of the feeder. During RIIO-1 this has proved to be an extremely efficient and effective approach to delivery of our programmes of work.

42.8. Where asset interventions do not require outages then the campaign approach will still be applied to maximise the opportunity for delivery of the same type of work across many locations. This enables efficient procurement through significant volumes of common works.

Sewage Treatment and Drainage, Tanks and Bunds (£6.6m)

Tanks and Bunds

43. Tanks and Bunds - Equipment Summary

43.1. This section of the case considers the investment in tanks and bunds that provide operational support and environmental impact management to our primary and secondary assets.

43.2. Tanks and bunds are used to ensure the safe storage of liquids for operational use or prior to disposal in the case of wastes. These liquids provide various functions such as lubricating compressor units (lube oil) and as fuel for standby generators (diesel). Waste oil and condensate are also stored in tanks on operational sites.

43.3. These liquids have hazardous properties and therefore the tank must be suitably designed, including provision of a bund or other secondary containment arrangement, to prevent pollution in the event of a tank failure or spill during maintenance / delivery or removal of liquids. In most cases this is a legal requirement.

43.4. Bunds may take the form of a separate brick or block-built containment wall surrounding the primary storage tank (typically a steel tank) or may be integral to the tank itself, for instance plastic or steel tanks within a tank. These are sometimes referred to as ‘double skinned’ or ‘integrally bunded’ tanks.

43.5. Tanks for lubrication oil, diesel and condensate are generally single skinned steel tanks with an external bund. Tanks for waste oil are all double skinned plastic tanks with an integral bund.

Redundancy

43.6. There is no redundancy for the bund as this is the asset that provides the secondary protection against pollution.

44. Tanks and Bunds - Problem Statement

44.1. All the tanks and bunds on the NTS sites are subject to deterioration. Many of the steel tanks and associated concrete bunds are over 30 years old. The steel tanks are subject to corrosion, both internally and externally. Examples have been found where the external surface of the tank is visually sound, when inspected internally significant corrosion is evident.

44.2. The bunds around the steel tanks on the older sites are subject to deterioration with spalling of the concrete and a potential to fail to contain liquids in the event of a tank failure.

44.3. The plastic, internally bunded, tanks have a fixed design life and need to be replaced before this to ensure that they are not subject to catastrophic failure.

Drivers for Investment

44.4. The key drivers for investment in the tanks and bunds assets are:

- Asset Deterioration
- Legislation

44.5. Bunds deteriorate over time and with use which leads to their inability to perform their required function. This can also result in them no longer complying with direct legislative requirements.

44.6. **Deterioration** – the assets are subject to several deterioration mechanisms

- the metal parts of the tanks are subject to corrosion which can lead to failure or the inability of any moving parts to operate
- the concrete bunds deteriorate due to age and environmental effects which in turn then exposes reinforcement which further deteriorates and spalls the concrete leading to further deterioration and ultimately structural failure
- the plastic tanks are subject to age-based deterioration of the material which is exacerbated by environmental impacts. Typically, these tanks fail catastrophically

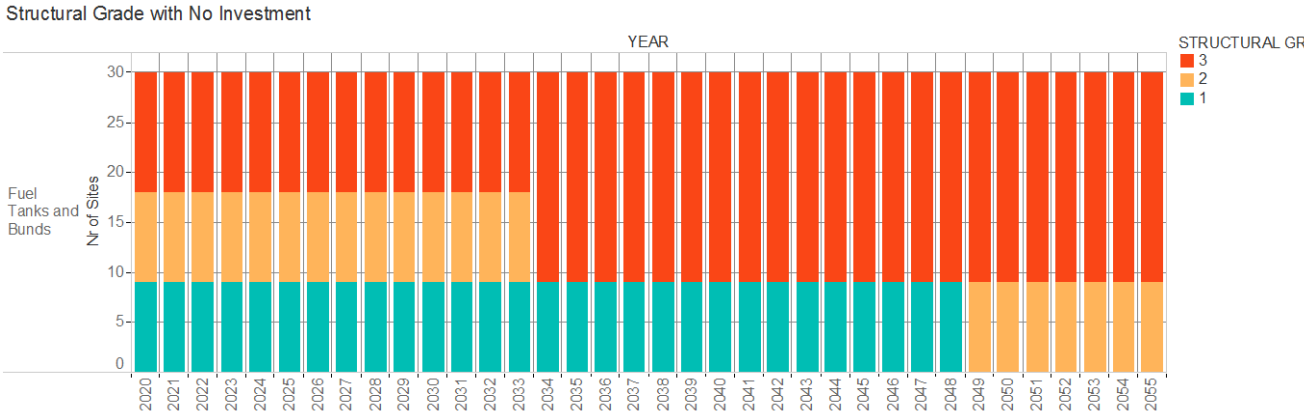
44.7. **Legislation –** maintaining the integrity of the tanks and bunds is essential to manage the risk of the loss of containment of fluids that are potentially harmful to the environment

Impact of No Investment

44.8. Lack of investment in the tanks and bunds will lead to their continued deterioration and potential failure to either contain the liquid in the tank or to contain any leakage from the tank or other spillage. There is therefore the potential for of loss of fluid to the environment leading to breach of environmental permits and non-compliance with general environmental legislation.

44.9. The chart below shows the count of tanks and bunds assets by structural integrity inspection grades varying over time given no investment. Around 40% of assets are assessed as grade 3 in 2018 increasing to nearly 70% by end of RIIO-3.

Structural Grades – No Investment



Desired Outcomes

44.10. The outcome of this investment is to:

- Ensure the risk of pollution from hazardous liquids on NTS sites is managed.
- Ensure the continued supply and receipt of the relevant lubricants, fuel and other fluids to and from our operational assets.

Example of the Problem

44.11. The photographs below show examples and a description for each structural condition grade for the bund assets. These are used for the site inspections and categorisation of the resulting grades. They are fully representative of the issues found on the sites.

Structural Condition Grades – Bund Assets

No Remedial Action Required	Pits and bunds are new or in good condition, no evidence of movement, cracking or surface deterioration. Any associated drains, seals, etc., are new or in good condition.		
❷	**Potential for disruption to service**		
Minor Remedial Action Required	Pits and bunds structures are showing signs of deterioration, e.g; corroded fixings, fine cracks, minor settlement, signs of water ingress. Arrange minor concrete repairs, replace / re-fix minor areas of damage, identify and where practical seal water damage. More significant deterioration should be recorded as a defect ensuring that all defect numbers are recorded in the report.		
❸	**High Risk of disruption to service**		
Remedial Action Required	Pits and bund type structures are significantly deteriorating, e.g; spalling of areas of concrete, evidence of corrosion from reinforcement, loose fixings, open cracks, leakage, evidence of movement such as loss of verticality, etc. Significant or widespread deterioration or evidence of recent movement or change, should be reported immediately to the Senior Engineer (Civils) and recorded as a defect ensuring that all defect numbers are recorded in the report. N.b. Inspection and reporting of defects in pipe / wall transitions are covered within CM/4 procedure.		

Spend Boundaries

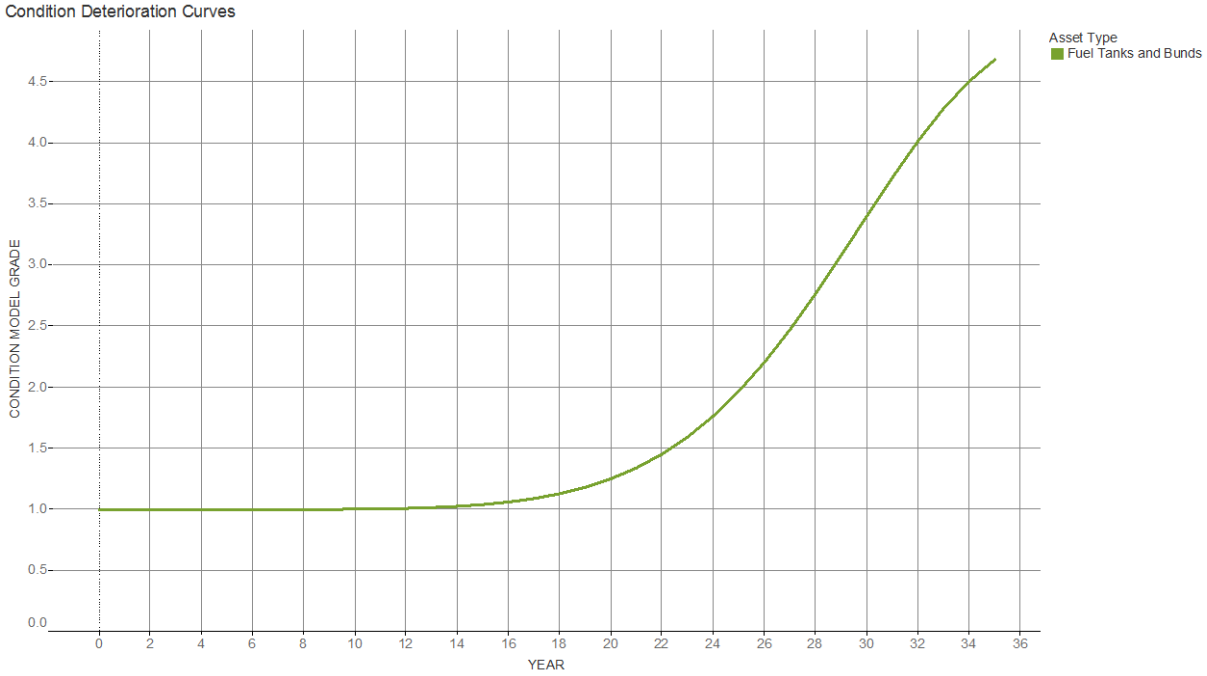
44.12. The proposed investment includes all external fixed bunds around tanks and the related tanks on the NTS, including any 'no-regrets' site investments at both St Fergus and Bacton to keep them safe and operational whilst the separate funding mechanism for the proposed projects are progressed via Uncertainty Mechanisms.

45. Tanks and Bunds - Probability of Failure

45.1. The chart below shows the condition deterioration curve for fuel tanks and bunds structural integrity asset types. The model uses the parameters derived within the development of our NOMS methodology showing how the asset degrades over time from Condition Model Grade 1 to Grade 5. Grade 5 is reached sometime after 35 years from new. Each grade is directly aligned to the asset health definitions used in RIIO-1.

Condition Deterioration Curve – Tanks and Bunds

Asset Health Scores	
AH1	New or as new
AH2	Good or serviceable condition
AH3	Deterioration, requires assessment or monitoring
AH4	Material deterioration, intervention requires consideration
AH5	End of serviceable life, intervention required



Probability of Failure

45.2. All Structural Integrity interventions are defined as consequential Interventions. This is because the prime function of Structural Integrity assets is to either support or protect enabling a dependent asset/site to perform its primary function of safely and reliably transporting gas. All risk benefits associated with Structural Integrity assets are therefore considered to align with the following definition of a consequential risk intervention:

Any intervention on a network asset, or other infrastructure asset, that modifies the probability of failure, or consequence of failure of **another network asset**. A consequential asset can include, for example:

- installation or removal of physical infrastructure designed to prevent damage to adjacent assets in the event of an asset failure (e.g. installation of a blast wall),

- addition or disposal that increases or decreases the resilience of a local or regional network and hence modifies the consequence of failure of other asset(s) in the locality or region.

Consequential Interventions

45.3. The table below shows the drivers for Structural Integrity asset investment that are defined

Structural Integrity Drivers

NARMs Asset Intervention Category	Secondary Asset Classes
Consequential Interventions (Non-risk tradeable)	Fuel tanks & bunds

45.4. Our NOMs Methodology attempts to model the indirect benefits delivered by these assets in terms of the reduction in PoF or Consequence of Failure (CoF) upon a related and/or adjacent asset (e.g. the relationship between the pipe support and the pipework it is supporting). These quantified, but indirect, impacts are used within the CBAs accompanying this justification report, but are not considered to be reliable enough for use as a NARMs monetised risk metric.

Structural Integrity Interventions

45.5. The table below provides the interventions for the structural integrity assets.

Interventions

Intervention	SAC	Intervention Category
A22.03.2.18 / Minor remediation works (Bacton)	Fuel tanks & bunds	Minor Refurbishment
A22.03.2.19 / Monitoring of Structural Integrity Assets (Bacton)	Fuel tanks & bunds	Minor Refurbishment
A22.03.2.20 / Relifing or Replacement of Tank Bunds (Bacton)	Fuel tanks & bunds	Replacement
A22.18.3.5 / Monitoring of Structural Integrity Assets	Fuel tanks & bunds	Survey
A22.18.3.6 / Minor remediation works	Fuel tanks & bunds	Minor Refurbishment
A22.18.3.7 / Relifing or Replacement of Tank Bunds	Fuel tanks & bunds	Replacement
A22.22.2.6 / Relifing or Replacement of Tank Bunds (St. Fergus)	Fuel tanks & bunds	Replacement

Data Assurance

45.6. All PoF and CoF values are taken from the National Grid Gas Transmission 'Methodology for Network Output Measures' (the Methodology). The Methodology was originally submitted for public consultation in April 2018, with three generally favourable responses received in May 2018. On this basis, Ofgem were happy to provisionally not reject the Methodology pending further work to:

- Produce a detailed Validation Report, confirming the validity of data sources used in the Methodology
- Test a range of supply and demand scenarios and incorporate an appropriate scenario to best represent Availability and Reliability risk

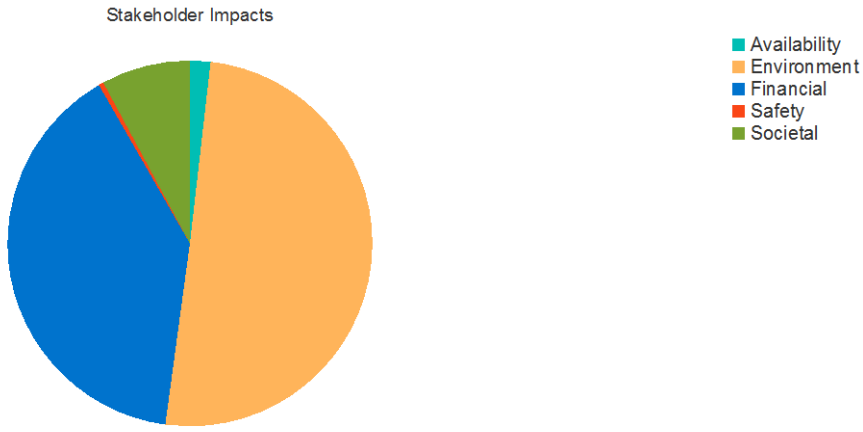
45.7. A review of the Methodology by independent gas transmission experts has been carried out and several improvements identified and incorporated.

45.8. At the time of writing, the final Validation Report has been submitted to Ofgem. We understand that once this work is complete Ofgem will formally “not reject” the Methodology and a License change progressed to restate our RIIO-1 targets in terms of monetised risk commenced.

46. Tanks and Bunds - Consequence of Failure

46.1. The pie chart below shows the impacts on outcomes for stakeholders that we expect from failures or defects occurring on fuel tanks and bunds structural integrity assets. The charts show the relative numbers of consequence events, not relative monetised risk.

Stakeholder Impacts



46.2. Fuel tanks store fuel and oil used for operation of critical assets. Bunds are associated with the fuel tank to prevent environmental damage associated with loss of hydrocarbons. The contribution of individual service risk measures towards the overall risk for Fuel Tanks and Bunds, is listed in order of significance:

- **Environmental risk** is the largest proportion of overall service risk and is associated with the cost of environmental clean-up, and potentially prosecutions associated with oil/fuel spills
- **Financial risk** is mostly associated with the costs of operating and maintaining the assets at the current level of risk. Clean-up and prosecutions costs are considered as Environment risk
- **Availability risk** is associated with the potential outages associated with the inability to supply or maintain a compressor train. through the loss of integrity of a fuel/oil tank
- **Societal risk** is associated with environmental impacts of off-site spills
- **Safety risk** is negligible, but is associated with potential fires caused by oil spills and risk of death or injury to employees

47. Tanks and Bunds - Options Considered

Potential Intervention Options

47.1. The following intervention categories apply to the tanks and bunds:

Repair

- Localised repair to any damaged / cracked concrete bunds / supports, repair any bund wall seals.

Refurbishment

- Confirm the integrity of steel tanks and all bunds. Replace any associated covers / fixings / drain / sump pump arrangements. Line any concrete bunds with water / oil proof membrane.

Replacement

- Remove existing tank and any bunding and pumping arrangements and re build as new. There is the option if it is structurally sound to retain the concrete bund, modifying supports to suit new tank. New ancillary assets are installed including covers / fixings / drains / sump pumps.
- Plastic, internally bunded, tanks are replaced in their entirety.

Intervention Unit Costs

47.2. The total RIIO-2 investment for Tanks and Bunds represents 3% of the Structural Integrity investment theme. 78% of unit costs that support the Tanks and Bunds investment are based on historical outturn cost data points, however these need to be verified. The remaining 22% of costs have been developed using other estimation methods due to the unavailability of outturn cost data and the broad spectrum of activities that can be performed to rectify the defect.

47.3. The table below provides the unit costs for all tanks and bunds interventions.

Intervention Unit Costs – Tanks and Bunds

Intervention	Cost (£)	Unit	Evidence	Data Points	Overall value in BP
Tanks and Bunds					
A22.18.3.5 / Monitoring of Structural Integrity Assets	[redacted]	Per asset	Estimated - Other	5	£234,815
A22.18.3.6 / Minor remediation works	[redacted]	Per site	Estimated - Other	0	£117,449
A22.18.3.7 / Relifing or Replacement of Tank Bunds	[redacted]	Per asset	Outturn	2	£1,562,617
A22.03.2.18 / Minor remediation works (Bacton)	[redacted]	Per site	Estimated - Other	0	£5,168
A22.03.2.19 / Monitoring of Structural Integrity Assets (Bacton)	[redacted]	Per asset	Estimated - Other	0	£12,915
A22.03.2.20 / Relifing or Replacement of Tank Bunds (Bacton)	[redacted]	Per asset	Estimated - Other	0	£28,006
A22.22.2.6 / Relifing or Replacement of Tank Bunds (St. Fergus)	[redacted]	Per asset	Estimated - Other	0	£36,069

Sewage Treatment and Drainage

48. Sewage Treatment and Drainage - Equipment Summary

48.1. Almost every site within the NTS, other than some small block valve sites, have drainage assets. These range from a single drainage channel at a site access road, through to a manned site with its own sewage treatment plant and storm water pumps.

48.2. Drainage is designed to prevent flooding and to stop liquid pollution leaving site, in accordance with the NG PPC Permit. It comprises all aspects of drainage including pipework (foul and surface water), land drains, manholes and manhole covers, and associated assets such as interceptors, pump chambers, pumps, headwalls. Interceptors are designed to stop liquid pollution such as oils leaving the site in accordance with environmental consents.

48.3. Sewage treatment plants are in place to process the effluent generated on site and allow it to be discharged into the environment in accordance with the terms of the individual site Discharge Consent.

49. Sewage Treatment and Drainage - Problem Statement

49.1. The drainage and sewage treatment assets are subject to deterioration, obsolescence and performance issues. Overall deterioration is leading to assets that are showing an increasing number of defects and failures leading to risks of failure to comply with environmental permits and legislation. The obsolescence of some of the electronic control systems increases the duration of any asset failures, further increasing the risk of non-compliance.

49.2. The changed patterns and volumes of water flows both internal and in particularly external to NTS site combined with blockage of drainage due to ground movement, root ingress is causing increased localised flooding and damage to NTS assets. Failure and in-effective land-drainage systems are causing liquefaction of subsoils giving rise to lack of foundation support and settlement.

Drivers for Investment

49.3. The key drivers for investment in the drainage and sewage treatment assets are:

- Obsolescence
- Asset Deterioration
- External Impacts

49.4. Drainage and Treatment deteriorate over time and with use which leads to their inability to perform their required function. This can also result in them no longer complying with direct legislative requirements. The obsolescence of some of the assets can mean, despite a comprehensive spares strategy, a risk of increased impact when they fail.

49.5. Obsolescence –the pit pumps and associated control equipment for some of the treatment plants are obsolete and spares are no longer available

49.6. Deterioration – Sewage Treatment and drainage assets are subject to several deterioration mechanisms:

- Wear of moving parts such as pumps, motors and any gearboxes
- Electronic component deterioration leading to end of life for electronic control systems
- Deterioration of the enclosures particularly the environmental deterioration of GRP
- The concrete manholes and other structure deteriorate due to age and environmental effects which in turn then exposes any reinforcement which further deteriorates and spalls the concrete leading to further deterioration and ultimately structural failure

49.7. External Impacts – drainage is mainly affected by:

- Drainage assets fail to perform due to cracked and crushed pipe, root ingress and ground movement

- Changed patterns of water flow both internal and external to the NG site results in the inability of the drainage to effectively manage the removal of water from the site surface or its subsoil

Impact of No Investment

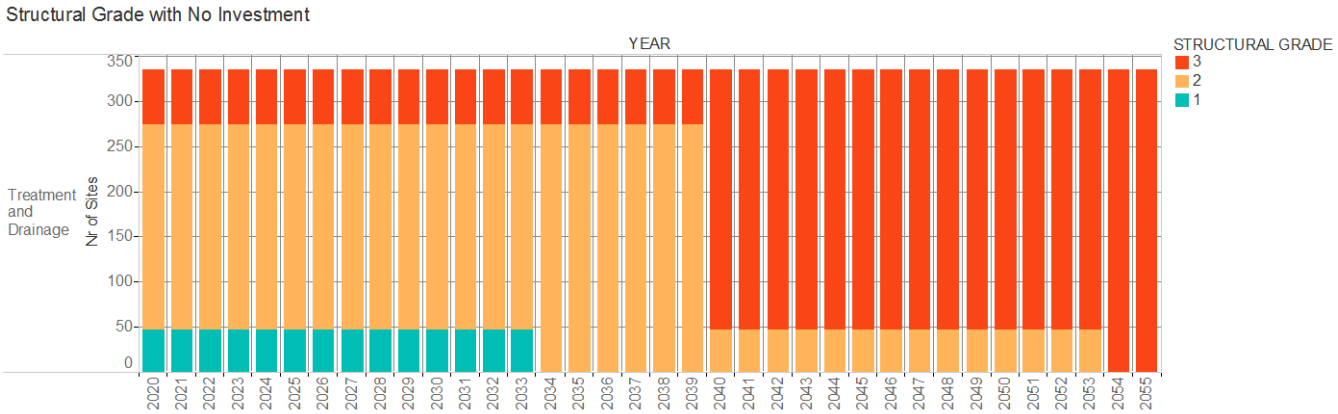
49.8. Lack of investment in the drainage and treatment assets will cause them to continue to deteriorate. Failure of the treatment works may cause failure environmental / discharge consents. Failure of the drainage may cause environmental damage and the is also the possibility of discharge consent failure if it is on a site subject to EA discharge consents.

49.9. Failure of drainage assets can quickly cause very significant damage to other assets. This can be direct water damage due to flooding. Failed and in-effective land-drainage systems can cause liquefaction of subsoils giving rise to lack of support of foundations and in some cases severe settlement, especially at sites which are prone to vibration, such as compressor stations.

49.10. NG operates a comprehensive spares management strategy by which assets that are removed from service are stored and reused as far as possible. This mitigates the issue of obsolescence to some extent and extends the useful life of assets for as long as practicable. However, spares and not limitless or fully comprehensive. Therefore, where an asset is obsolete and no spare is available the repair time and impact for any failure is increased.

49.11. The chart below shows the count of drainage and treatment assets by structural integrity inspection grades varying over time given no investment. Around 20% of assets are assessed as grade 3 in 2018 with nearly 70% assessed as grade 2.

Structural Grades – No Investment



Desired Outcomes

49.12. The outcome of this investment is to:

- Ensure that NG maintain compliance with all Environmental PPC permits through effective foul drainage and sewage treatment.
- Ensure that the surface and ground water is managed so as not to impact the operation, deterioration or availability of the primary assets.

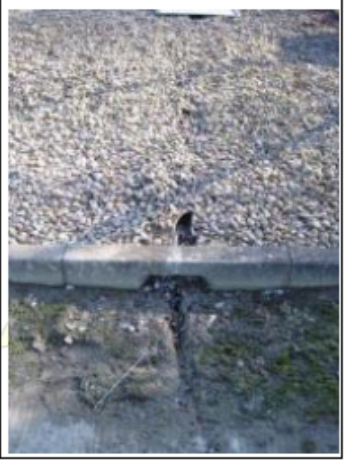
Example of Problem

49.13. The photographs below show examples and a description for each structural condition grade for the treatment and drainage assets. These are used for the site inspections and categorisation of the resulting grades. They are fully representative of the issues found on the sites.

Structural Condition Grades - Treatment, Interceptor tanks and Pumps

Visual Grade	Description	Examples	
1	**No likely risk of disruption to service.**		
No Remedial Action Required	Drainage interceptor or separation tanks, sewage treatment equipment & associated pumps are new or in good condition, no records of blockages or flooding. Any access arrangements and new or in good condition.		
2	**Potential for disruption to service**		
Minor Remedial Action Required	Drainage interceptor or separation tanks, sewage treatment equipment & associated pumps are showing signs of ground water ingress, screens, pump controls or access arrangements in poor but serviceable condition. No recent records of blockages or flooding. Any associated access arrangements and equipment, etc. are in serviceable condition. Arrange minor repairs, cleaning / replace / re-fix any loose screens. Confirm servicing of pumps / sewage treatment plants.		
3	**Blockages and flooding likely to disrupt service / cause environmental damage**		
Remedial Action Required	Drainage interceptor or separation tanks, sewage treatment equipment & associated pumps are failing, blockages occurring, pump controls tripping out or access arrangements are showing signs of failure. Raise a defect for issues identified and record all defect numbers in the report.		

Structural Condition Grades - Drainage

Visual Grade	Description	Examples	
1	**No likely risk of disruption to service.**		
No Remedial Action Required	Manhole covers and chambers new or in good condition, no records of blockages or flooding, Direction of flow markers in place. Any associated; valves, headwalls to local ditches, sampling points, etc. are accessible and new or in good condition.		
2	Potential for disruption to service		
Minor Remedial Action Required	Manhole covers or/and concrete surround is showing signs of deterioration /potential for movement, chambers showing signs of ground water ingress, access arrangements in poor condition. Debris / silting / standing water evident in channel through chamber. No recent records of blockages or flooding, direction of flow markers in place. Any associated; valves, headwalls to local ditches, sampling points, etc. are difficult to access but serviceable condition. Arrange minor repairs, replace / re-fix covers, CCTV & jetting of drains to identify root ingress/ pipe breakage.		
3	**Blockages and flooding likely, trip or fall hazards present.**		
Remedial Action Required	Manhole covers broken or coming loose, chambers showing signs of ground water ingress, access arrangements loose / in poor condition. Recent records of blockages or flooding. Any associated; valves, headwalls to local ditches, sampling points, etc. are overgrown / inaccessible and in poor condition. Raise a defect for issues identified and record all defect numbers in the report.		

Spend Boundaries

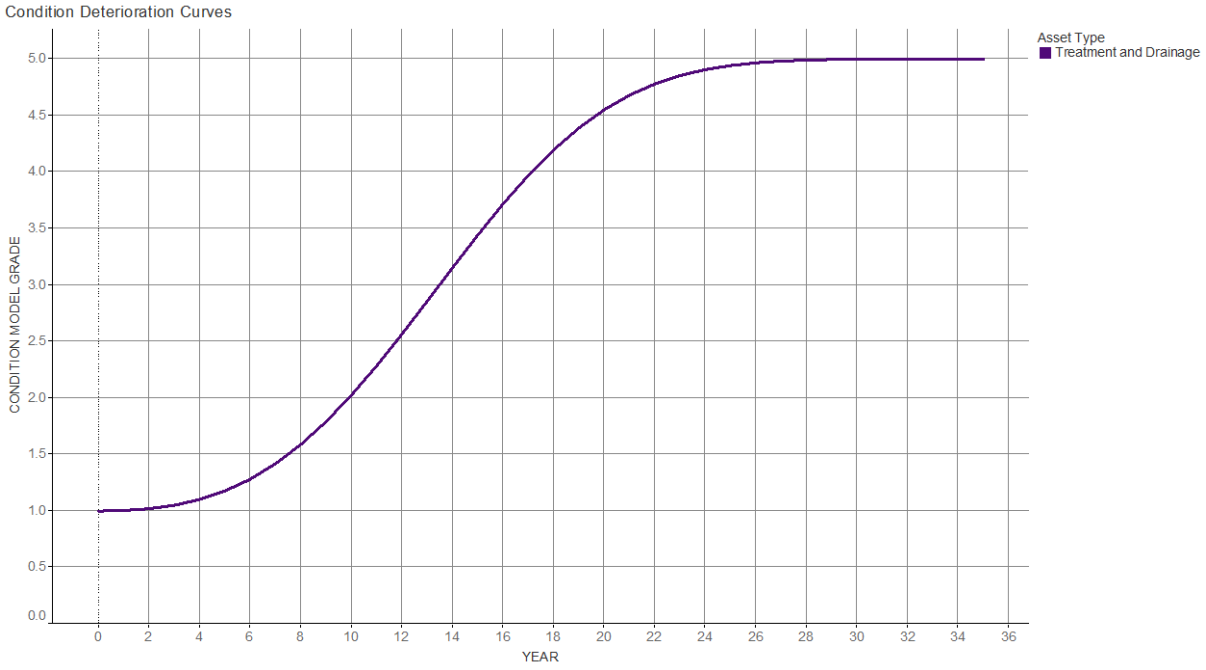
49.14. The proposed investment includes all fixed drainage and treatment assets on the NTS, including any 'no-regrets' site investments at both St Fergus and Bacton to keep them safe and operational whilst the separate funding mechanism for the proposed projects are progressed via Uncertainty Mechanisms.

50. Sewage Treatment and Drainage - Probability of Failure

50.1. The chart below shows the condition deterioration curve for drainage and treatment structural integrity asset types. The model uses the parameters derived within the development of our NOMS methodology showing how the asset degrades over time from Condition Model Grade 1 to Grade 5. Grade 5 is reached at around 30 years from new. Each grade is directly aligned to the asset health definitions used in RIIO-1.

Condition Deterioration Curve

Asset Health Scores	
AH1	New or as new
AH2	Good or serviceable condition
AH3	Deterioration, requires assessment or monitoring
AH4	Material deterioration, intervention requires consideration
AH5	End of serviceable life, intervention required



Probability of Failure

50.2. All Structural Integrity interventions are defined as consequential Interventions. This is because the prime function of Structural Integrity assets is to either support or protect enabling a dependent asset/site to perform its primary function of safely and reliably transporting gas. All risk benefits associated with Structural Integrity assets are therefore considered to align with the following definition of a consequential risk intervention:

50.3. Any intervention on a network asset, or other infrastructure asset, that modifies the probability of failure, or consequence of failure of **another network asset**. A consequential asset can include, for example:

- installation or removal of physical infrastructure designed to prevent damage to adjacent assets in the event of an asset failure (e.g. installation of a blast wall),

- addition or disposal that increases or decreases the resilience of a local or regional network and hence modifies the consequence of failure of other asset(s) in the locality or region.

Consequential Interventions

50.4. The table below shows the drivers for Structural Integrity asset investment that are defined

Structural Integrity drivers

NARMs Asset Intervention Category	Secondary Asset Classes
Consequential Interventions (Non-risk tradeable)	Civil assets – drainage

50.5. Our NOMs Methodology attempts to model the indirect benefits delivered by these assets in terms of the reduction in PoF or Consequence of Failure (CoF) upon a related and/or adjacent asset (e.g. the relationship between the pipe support and the pipework it is supporting). These quantified, but indirect, impacts are used within the CBAs accompanying this justification report but are not considered to be reliable enough for use as a NARMs monetised risk metric.

Structural Integrity Interventions

50.6. The table below provides the interventions for the structural integrity assets.

Interventions by Category

Intervention	SAC	Intervention Category
A22.03.2.7 / Minor remediation works (Bacton)	Civil assets - drainage	Minor Refurbishment
A22.03.2.8 / Monitoring of Structural Integrity Assets (Bacton)	Civil assets - drainage	Minor Refurbishment
A22.03.2.9 / Major remediation works (Bacton)	Civil assets - drainage	Major Refurbishment
A22.18.3.1 / Monitoring of Structural Integrity Assets	Civil assets - drainage	Survey
A22.18.3.2 / Minor remediation works	Civil assets - drainage	Minor Refurbishment
A22.18.3.3 / Damaged and Broken Drainage Assets at AGIs Minor Refurb	Civil assets - drainage	Minor Refurbishment
A22.18.3.4 / Replace Obsolete Sewage Treatment Assets at Compressor Sites	Civil assets - drainage	Replacement
A22.22.2.4 / Damaged and broken drainage assets - Replacement (St. Fergus)	Civil assets - drainage	Replacement

Data Assurance

50.7. All PoF and CoF values are taken from the National Grid Gas Transmission 'Methodology for Network Output Measures' (the Methodology). The Methodology was originally submitted for public consultation in April 2018, with three generally favourable responses received in May 2018. On this basis, Ofgem were happy to provisionally not reject the Methodology pending further work to:

- Produce a detailed Validation Report, confirming the validity of data sources used in the Methodology

- Test a range of supply and demand scenarios and incorporate an appropriate scenario to best represent Availability and Reliability risk

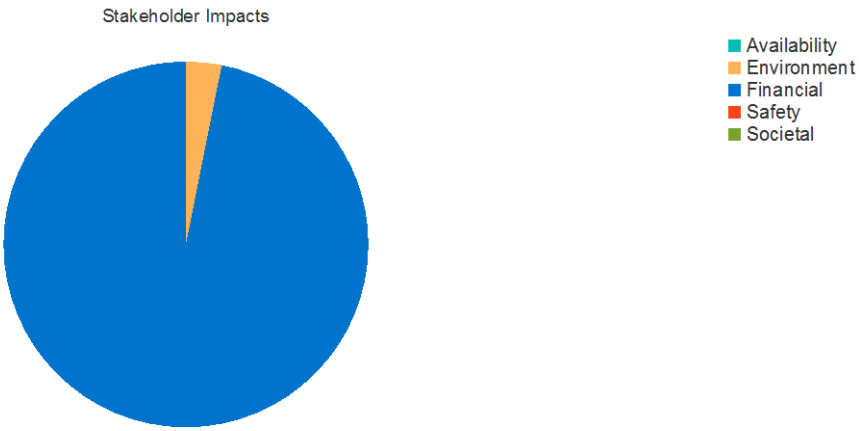
50.8. A review of the Methodology by independent gas transmission experts has been carried out and several improvements identified and incorporated.

50.9. At the time of writing, the final Validation Report has been submitted to Ofgem. We understand that once this work is complete Ofgem will formally “not reject” the Methodology and a License change progressed to restate our RIIO-1 targets in terms of monetised risk commenced.

51. Sewage Treatment and Drainage - Consequence of Failure

51.1. The pie chart below shows the impacts on outcomes for stakeholders that we expect from failures or defects occurring on drainage and treatment structural integrity assets. The charts show the relative numbers of consequence events, not relative monetised risk.

Stakeholder Impacts



51.2. Treatment and Drainage assets ensure that a site does not flood, thus preventing safe and reliable operation of assets. Treatment of wastewater is required if site processes mean that water to be returned to the environment is non-compliant. The contribution of individual service risk measures towards the overall risk for Treatment and Drainage assets, is listed in order of significance:

- Financial risk is mostly associated with the costs of operating and maintaining the asset at the current level of risk. Any work extending the life of these assets is considered as proactive maintenance and is not included in the baseline monetised risk value
- Environmental risk is related to the costs of environmental prosecution if wastewater does not adhere to the required standards when leaving the site

52. Sewage Treatment and Drainage - Options Considered

Potential Intervention Options

52.1. The following intervention categories apply to the drainage and treatment assets:

Repair

- Replace broken sections of pipe or manhole chamber covers and frames. Repair Sewage Treatment plant by replacing key components such as motors / bearings, control panels.

Refurbishment

- Full CCTV survey, jetting, root cutting / clearance tools. Change covers and frames of manhole chambers where needed and renew individual chambers where necessary. Full drain down and replacement of all moving parts, renew soak away bed material.

Replacement

- Complete relaying of drain / sewer and manholes. Replacement of the sewage plant with modern more effective equipment.

Intervention Unit Costs

52.2. The total RIIO-2 investment for Sewage Treatment and Drainage represents 6% of the Structural Integrity investment theme. 69% of unit costs that support the Sewage Treatment and Drainage investment are based on historical outturn cost data points, which need to be verified. The remaining 31% of costs have been developed using other estimation methods due to the unavailability of outturn cost data and the broad spectrum of activities that can be performed to rectify the defect.

52.3. The table below provides the unit costs for all the potential Sewage Treatment and Drainage interventions.

Intervention Unit Costs – Sewage Treatment and Drainage

Intervention	Cost (£)	Unit	Evidence	Data Points	Overall value in BP
Sewage Treatment and Drainage					
A22.18.3.1 / Monitoring of Structural Integrity Assets	[redacted]	Per asset	Estimated - Other	5	£553,700
A22.18.3.2 / Minor remediation works	[redacted]	Per site	Estimated - Other	0	£276,948
A22.18.3.3 / Damaged and Broken Drainage Assets at AGIs Minor Refurb	[redacted]	Per site	Outturn	2	£2,380,584
A22.18.3.4 / Replace Obsolete Sewage Treatment Assets at Compressor Sites	[redacted]	Per site	Outturn	2	£772,917
A22.03.2.7 / Minor remediation works (Bacton)	[redacted]	Per site	Estimated - Other	0	£25,265
A22.03.2.8 / Monitoring of Structural Integrity Assets (Bacton)	[redacted]	Per asset	Estimated - Other	0	£63,139
A22.03.2.9 / Major remediation works (Bacton)	[redacted]	Per site	Estimated - Other	0	£134,673
A22.22.2.4 / Damaged and broken drainage assets – Replacement (St. Fergus)	[redacted]	Per site	Estimated - Other	0	£360,694

Business Case

In this section, we set out our overall investment plan for Sewage Treatment and Drainage Assets. This section demonstrates why the proposed investment levels are the right levels to ensure the health and reliability of these assets for the investment period and beyond.

53. Business Case Outline and Discussion

Key Business Case Drivers Description

53.1. The key drivers for investment in the Sewage Treatment and Drainage assets are:

- Legislation
- Asset Deterioration

Business Case Summary

53.2. In appraising asset health investment, we have considered how assets can impact on several outcomes:

- Reliability risk
- Environmental risk
- Safety risk
- Impact on wider society

53.3. Maintaining the health of these assets is important in ensuring they continue to ensure compliance with environmental permits and manage the risk of surface and ground water impacts on the assets.

Outcomes Delivered

53.4. The outcome of this investment is to:

- Ensure the risk of pollution from hazardous liquids on NTS sites is managed and that NG maintain compliance with all Environmental PPC permits through effective foul drainage and sewage treatment.
- Ensure the continued supply and receipt of the relevant lubricants, fuel and other fluids to and from our operational assets.
- Ensure that the surface and ground water is managed so as not to impact the operation, deterioration or availability of the primary assets.

Stakeholder Support

53.5. Consumer and stakeholder research and engagement has been integral to the development of our asset health investment plans. Early discussions realised that to engage in meaningful dialogue, our plan outputs should be presented at a programme rather than asset level of detail. This is due to the integrated nature of our Asset Health plan which makes it challenging to disaggregate and engage on individual elements. For details of our stakeholder engagement approach please refer to ‘I want to take gas on and off the system where and when I want’ [Chapter 14 of the GT submission].

54. Programme Options

Programme Option Overview

54.1. Our aim in developing the investment plan is to deliver value to our consumers and stakeholders. Hence, we have considered a range of options from the do nothing position through to reductions in risk across all the measures. These have been used to explore the credible options for varying the investment and the appraising the impacts on our legal compliance, risk position and stakeholders.

54.2. In developing our plan, the following options have been considered for investment in the sewage treatment, drainage, tanks and bunds assets. Please note that all programme options include any fixed 'no-regrets' investments associated with the Bacton and St Fergus sites.

Baseline – Do Nothing

54.3. The impact of no investment in our Sewage Treatment, Drainage, Tanks and Bunds over a 10-year period is a small increase in service risk across all service risk categories. This option includes the reactive only investment across all Sewage Treatment, Drainage, Tanks and Bunds and is the option against which all the other options are compared.

Programme Option 1 – Fix on Fail

54.4. This option does not include any monitoring of the sewage treatment, drainage, tanks and bunds assets and undertakes minimal reactive minor refurbishment to the assets as and when they fail. No proactive replacement is undertaken with only the minimal amount of either minor or major refurbishment work to the function of the asset.

Programme Option 2 – Primary Proactive Re-lifing

54.5. This option considers minimal proactive re-lifing of those assets that have a direct potential impact on the primary assets. Only the worst grade assets are fully assessed and considered for re-lifing (refurbishment / replacement) investment. All other assets are fixed on failure / non-compliance with the minimal amount of either minor or major refurbishment work undertaken to restore the function of the asset.

Programme Option 3 – Minimal Proactive Re-lifing

54.6. This option considers minimal proactive re-lifing across all asset types with only the oldest and worst condition/performing assets fully assessed and considered for re-lifing investment. All other assets are fixed on failure / non-compliance with the minimal amount of either minor or major refurbishment work undertaken to restore function of the asset.

Programme Option 4 – Risk Based Re-lifing

54.7. This option considers risk based re-lifing of the assets based on their condition, criticality and age. A decision on the level of re-lifing (refurbishment / replacement) is then made. There is some allowance for reactive fix on fail which will consist of the most appropriate minor / major refurbishment or replacement.

Programme Option 5 - Increased Proactive Re-lifing

54.8. This option considers increased proactive re-lifing based on asset condition with all assets considered for replacement at an earlier condition grade. A reduced allowance for fix on fail is included for some assets which deteriorate earlier in their lifecycle.

Programme Options Summary

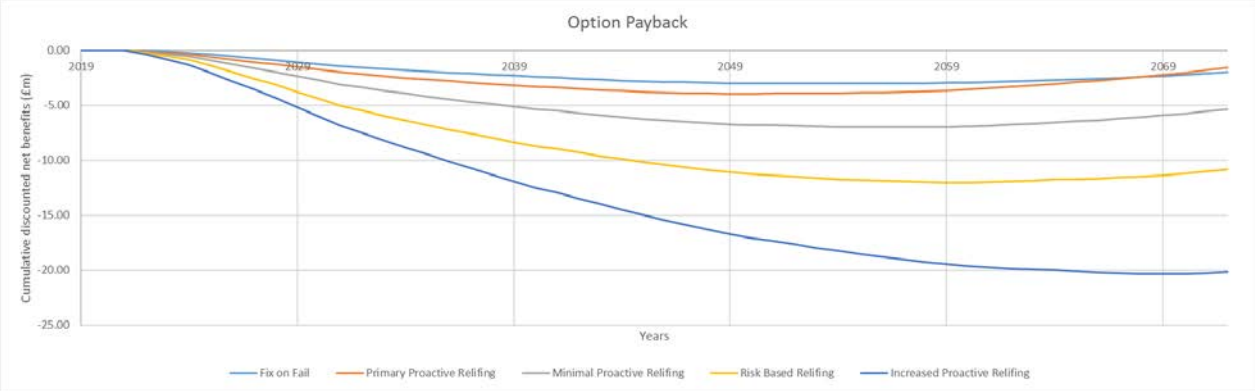
54.9. In considering the CBA for each of the programme options, a summary of all of the potential programme options is provided in the table below.

Potential Programme Options

Option	RIIO-2 Invest' £ m	RIIO-3 Invest' £ m	PV Costs £ m	PV benefits £ m	Net NPV £ m	CB Ratio	Payback Period (years)
1 - Fix on Fail	£1.85	£2.63	£5.33	£2.76	£(2.57)	0.52	-
2 - Primary Proactive Re-lifing	£2.71	£3.42	£7.76	£5.00	£(2.76)	0.64	-
3 - Minimal Proactive Re-lifing	£4.12	£5.42	£12.28	£5.93	£(6.35)	0.48	-
4 - Risk Based Re-lifing	£6.57	£8.98	£19.32	£7.67	£(11.65)	0.40	-
5 - Increased Proactive Re-lifing	£9.06	£11.36	£27.88	£7.68	£(20.21)	0.28	-

54.10. The graph shows the cumulative discounted NPV of the net benefit for each of the investment options.

Option Payback – Net NPV



Programme Options Selection

54.11. None of the options are cost beneficial over the 45-year analysis period. The selection of the preferred option has been based on an assessment of the level of risk, maintaining our compliance with legislation and delivering value for consumers and stakeholders. The outcomes associated with each option are provided below:

Programme Option 1 – Fix on Fail

54.12. This option results in increased reactive re-lifing (i.e. fix on fail) across most of the Sewage Treatment, Drainage, Tanks and Bunds asset types. As little or no monitoring is being undertaken assets are not worked on until they fail or are deemed non-compliant, so may be an effect on the availability of the compressors and other primary assets that impact the service delivered by the NTS. The overall environmental and compliance risk from structural assets is increased. Reactive re-lifing is not a long-term solution for the assets so this option will defer significant expenditure to after RIIO-2 and RIIO-3 and increase the overall whole life costs of the assets.

Programme Option 2 – Primary Proactive Re-lifing

54.13. Whilst re-lifing some of the worst condition and oldest assets that directly affect other primary assets or safety, this option still results in unacceptable levels of impact on the primary assets and increases in environmental and compliance risk. Significant expenditure is still deferred outside RIIO-2 and RIIO-3.

Programme Option 3 – Minimal Proactive Re-lifing

54.14. Whilst re-lifing some of the worst condition and oldest assets this option still results in unacceptable levels of impact on the primary assets and increases in environmental and compliance risk. Significant expenditure is still deferred outside RIIO-2 and RIIO-3.

Programme Option 4 – Risk Based Re-lifing

54.15. A risk based re-lifing of the assets through a considered and appropriate mix of proactive major / minor refurbishment and replacement combined with some reactive fix on fail and maintains the levels of environmental and compliance risk impact to current levels. There is minimal deferment of expenditure outside the RIIO-2 and RIIO-3 period. This option enables an acceptable level of investment to be maintained across the short and medium terms to manage the level of performance and risk.

Programme Option 5 - Increased Proactive Re-lifing

54.16. Increased proactive replacement and refurbishment reduces the risk of impacting the availability of operational assets and the associated service performance of the NTS. The number of failed assets is minimised however this is at the expense of significantly increased investment in RIIO-2 and RIIO-3. This level of investment is unacceptable to stakeholders and results in an unachievable and unacceptable number of outages on the NTS to enable the work to be undertaken.

Preferred Option

54.17. Our preferred option is Option 4 to maintain the current level of risk through a risk based relifing programme. Some of the other options require less investment and are more cost beneficial. However, these options do not meet the required outcomes of ensuring: compliance with environmental legislation and individual site permits; the continued supply and receipt of the relevant lubricants, fuel and other fluids to operational plant; and that the surface and ground water is managed on all sites.

54.18. Delivering these outcomes is consistent with feedback from our stakeholder engagement who wanted at least the current level of risk maintained. Our chosen option meets the desired outcomes at least whole life cost.

54.19. A complete explanation of the selected option is provided in the next section.

55. Decision Approach and Benefits - Tanks and Bunds

55.1. In this section, we set out our investment decision approach for tanks and bunds together with the benefits of the investment.

Key Drivers

55.2. The key drivers for investment in the tanks and bunds assets are:

- Legislation
- Asset Deterioration

Investment Decision Approach

55.3. To deliver the outcomes for the investment period the fuel tank and bunds assets require a mixture of the intervention categories. The predicted volumes of investment for the period are derived from:

- Analysis of historical investment
- Knowledge from the RIIO-1 inspections
- Current defects
- Site criticality

55.4. This has identified individual investments for 48 waste oil tanks on 23 sites during the period.

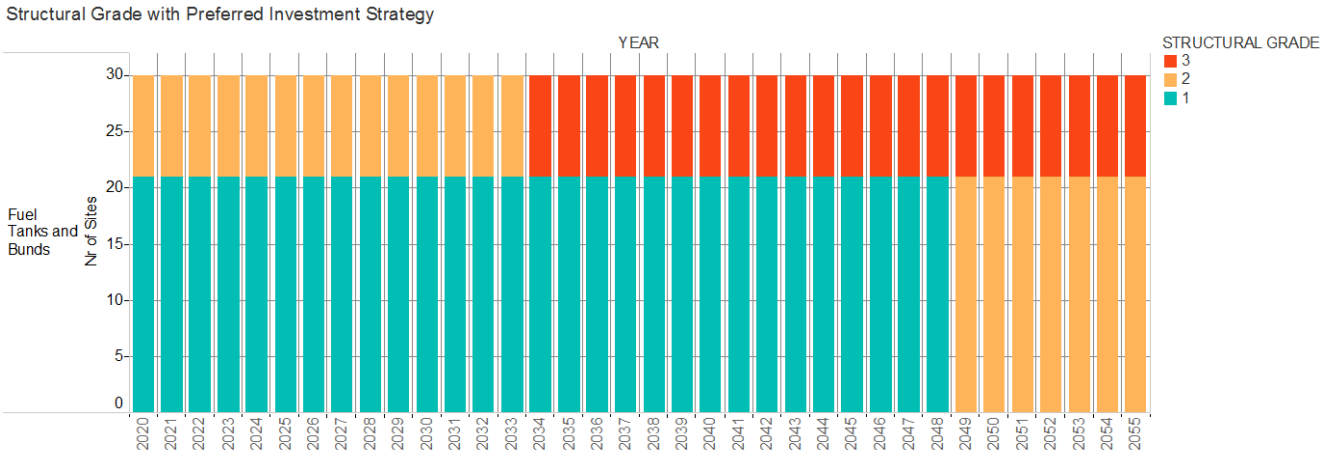
55.5. This investment will return the bunds that have deteriorated to an unacceptable condition to ensure that they can perform their function. Manage the deterioration of the remaining assets at minimum whole life cost to ensure that they do deteriorate to an unacceptable state. It will also replace all ‘plastic’ tanks within their design life to prevent the risk of catastrophic failure.

55.6. The proposed mix of interventions and programme of work will be continually reassessed and reprioritised based on the ongoing inspection and monitoring programme including other defects or plant status issues that are identified.

Benefits of the Investment

55.7. The chart below shows the count of fuel tanks and bunds assets by structural integrity inspection grades varying over time assuming the preferred investment option is applied. This shows that with the preferred investment option, the structural grade 3 assets are returned to grade 1. However, with ongoing deterioration, we expect that there will be again almost 30% of fuel tanks and bunds assets reaching grade 3 at the start of T4 which will require investment.

Structural Grades – Preferred Investment Strategy



56. Decision Approach and Benefits - Sewage Treatment and Drainage

56.1. In this section, we set out our investment decision approach for sewage treatment and drainage together with the benefits of the investment.

Key Drivers

56.2. The key drivers for investment in the drainage and treatment plant assets are:

- Obsolescence
- Asset Deterioration
- External Impacts

Investment Decision Approach

56.3. To deliver the outcomes for the investment period the drainage and treatment plant assets require a mixture of the intervention categories. The investment proposed in the period is discussed below.

Treatment Plant – Replacement:

56.4. An individual assessment of the treatment assets has identified 3 treatment plants that have deteriorated to the point where they are no longer meeting performance standards. Some of the equipment on these plants is also obsolete so when failures occur the time of the impact is extended.

Treatment Plant - General Deterioration:

56.5. The investment proposed is to move to a proactive risk-based inspection, monitoring and intervention regime to manage the treatment plant assets. The forecast level of replacement, refurbishment and repair has been based on current inspection and monitoring results combined with historic data.

Other Drainage Assets - General Deterioration:

56.6. The investment proposed is to move to a proactive risk-based inspection, monitoring and intervention regime to manage the treatment plant assets. The forecast level of replacement, refurbishment and repair has been based on current inspection and monitoring results combined with historic data. By the end of RIIO-3 40% of all drainage is brought back to a structural grade of 2 and that all those already in grade 2 are prevented from becoming Grade 3.

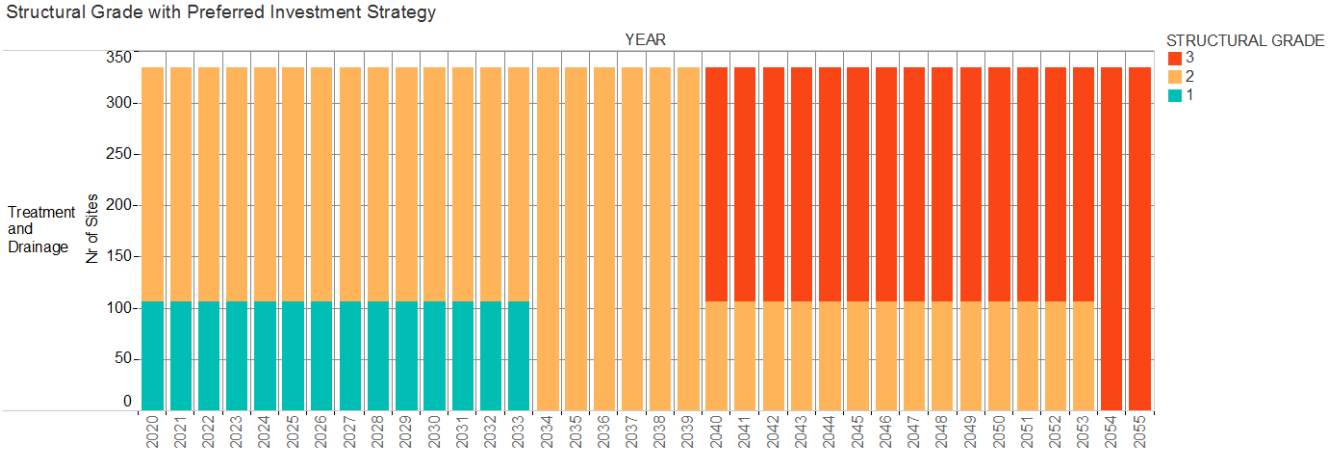
56.7. The proposed mix of interventions and programme of work will be continually reassessed and reprioritised based on the ongoing inspection and monitoring programme including other defects or plant status issues that are identified.

Benefits of the Investment

56.8. The investment will achieve the following improvements in the drainage and treatment assets.

56.9. The chart below shows the count of drainage and treatment assets by structural integrity inspection grades varying over time assuming the preferred investment option is applied. This shows that with the preferred investment option, the structural grade 3 assets are returned to grade 1 and with ongoing deterioration, the assets remain at grade 1 or 2 until 2040.

Structural Grades – Preferred Investment Strategy



57. Business Case Summary

57.1. In this section we set out our overall investment plan for pipework, coating, cladding and cathodic protection.

Preferred option

57.2. To deliver the required outcomes for all our stakeholders we have developed the most effective combination of efficient interventions. These form the programme of work for the treatment and drainage assets in the investment period. [redacted]

Intervention Volumes

[redacted]

Asset Health Spend Profile

57.3. The profile of investment in the treatment and drainage assets, driven from the derived volumes of work and the efficient unit costs, for the period is shown is the table below:

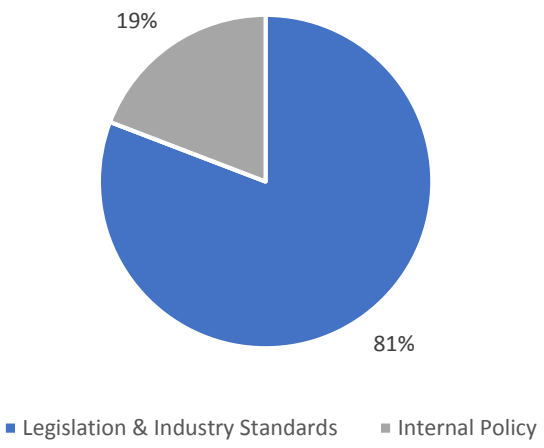
Investment Profile

Investment (£ 000's)	RIIO-2					RIIO-3				
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Civil assets - drainage	808	864	905	1,017	974	954	951	951	951	848
Fuel tanks & bunds	73	84	87	881	872	868	867	867	867	857
Total	881	949	992	1,897	1,846	1,821	1,819	1,819	1,819	1,705
	6,565					**8,983**				

Intervention Drivers

57.4. The following chart shows the breakdown of investment across each of the intervention drivers. This shows that the majority of the investment consists of interventions that are required to meet legislative requirements and are based on accepted industry standards.

RIIO-2 Sewage Treatment and Drainage Intervention Drivers[6]



Programme CBA

57.5. We are targeting an appropriate level of asset health investment to mitigate the reliability, safety and environmental risks from an ageing asset base.

57.6. In line with HM Treasury Green Book advice and Ofgem guidance we have appraised whether investment in treatment and drainage assets is value for money. We have considered costs over a 45-year period in a full cost benefit analysis (CBA).

57.7. The CBA shows that investment in these assets is not cost beneficial over the 45-year period. This is due to limitations in our modelling of low frequency, high consequences events, such as environmental prosecutions.

Cost Benefit Analysis[7]

	10 years	20 years	30 years	45 years
Present Value costs (£m)	£5.37	£10.23	£14.38	£19.32
Present Value H&S benefits (£m)	£0.00	£0.01	£0.02	£0.05
Present Value non H&S benefits (£m)	£0.33	£1.27	£3.02	£7.62
Net Present Value (£m)	£(5.04)	£(8.96)	£(11.35)	£(11.65)

57.8. We have challenged whether this is the right programme of work. In developing our plans and making our decision we have been fully cognisant of the need to develop plans that are value for money, acceptable, affordable and deliverable.

57.9. There are no other options for investment in the sewage treatment, drainage and tanks and bunds that deliver the required performance at a level of risk that is acceptable. These assets are essential in ensuring our compliance with

[6] See Appendix A for intervention driver category definitions

[7] A14.19.3 Sewage Treatment and Drainage CBA

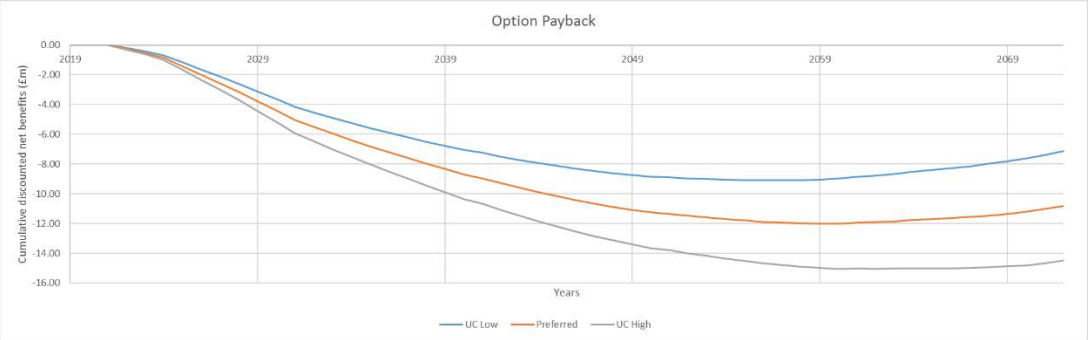
environmental legislation and individual site permits. In addition, the tanks also provide essential lubrication and fuel to our operational assets, such as compressors and their performance is essential to maintaining their overall availability.

57.10. Our inspection, monitoring and condition approach with early intervention is widely accepted as the lowest whole life cost of managing these long-life assets. In developing the proposed programme of work, we aimed to achieve the optimal balance between the level of investment and the risk to outcomes. We believe we have achieved this through a programme of re-lifing a proportion of the assets on a site by site basis whilst managing any individual defects on other sites on a case by case basis.

57.11. This approach achieves the balance of ensuring the assets remain fit for purpose in the medium term whilst maintaining affordable and deliverable levels of investment in the short term.

57.12. We have used the potential range of unit cost variance to assess the sensitivity of the Cost Benefit Analysis to the upper and lower limits. The graph below shows the results of this compared to the preferred option.

Net Benefits of Upper and Lower Unit Cost Sensitivity



57.13. Whilst the level of cost benefit changes as the unit costs vary, all the investment remains non-cost beneficial across the range of unit costs. The potential range of unit costs does not therefore change our decision.

57.14. The level of investment will ensure we successfully manage asset deterioration and obsolescence, whilst meeting our legal obligations.

Preferred Option

58. Preferred Option Scope – Buildings, Security and Access

58.1. The section summarises our preferred investment plan required to deliver acceptable and affordable outcomes for our stakeholders.

Preferred option

58.2. To deliver the required outcomes for all our stakeholders we have developed the most effective combination of efficient interventions. These form the programme of work for the treatment and drainage assets in the investment period. [redacted]

Intervention Volumes

[redacted]

Asset Health Spend Profile

58.3. The profile of investment in the treatment and drainage assets, driven from the derived volumes of work and the efficient unit costs, for the period is shown is the table below:

Investment Profile

Investment (£ 000's)	RIIO-2					RIIO-3				
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Civil assets - drainage	808	864	905	1,017	974	954	951	951	951	848
Fuel tanks & bunds	73	84	87	881	872	868	867	867	867	857
Total	881	949	992	1,897	1,846	1,821	1,819	1,819	1,819	1,705
	6,565					**8,983**				

Delivery Planning

58.4. At this point in time the delivery of our RIIO-2 and RIIO-3 plans are in principle deliverable based on initial assessments of work. We will regularly review the plan to consider any known or changing constraints, customer impacts and bundling opportunities. In the event of churn our plan must be reoptimised to reflect the impact of the change and provide an opportunity to reconsider the efficient timing of delivery.

58.5. These items may not need outages or pressure reductions to achieve access, however in the case of ducting or buildings the isolation of assets may be necessary to avoid undesirable operations for example via damage to cabling. Fencing and access projects may require pressure reductions when crossing services.

58.6. In all cases a systematic approach therefore maximises the work undertaken in any outage whilst ensuring efficient delivery through minimised project overheads.

58.7. This approach is particularly effective when applied at a feeder level or for a whole site. In which case the preparatory inspection, investigation, risk assessment, planning and procurement activities can be completed as far as possible before the outage. This allows the maximum amount of intervention and risk reduction to be bundled into a single ‘campaign’ across the length of the feeder. During RIIO-1 this has proved to be an extremely efficient and effective approach to delivery of our programmes of work.

58.8. Where asset interventions do not require outages then the campaign approach will still be applied to maximise the opportunity for delivery of the same type of work across many locations. This enables efficient procurement through significant volumes of common works.

Appendices

Appendix A – Intervention Driver Categories

Intervention Driver Categories

	Name	Definition
A	Legislation & Industry Standards	Intervention required to ensure compliance with relevant safety legislation and/or adopted industry standards.
B	OEM Guidance	Intervention recommended by OEM to maintain intended asset performance and safe operation. Any deviation from this guidance shall be specifically risk-assessed to ensure compliance with relevant safety legislation.
C	Internal Policy	Internal policy defined intervention required to maintain asset performance, and to align with relevant safety legislative requirements